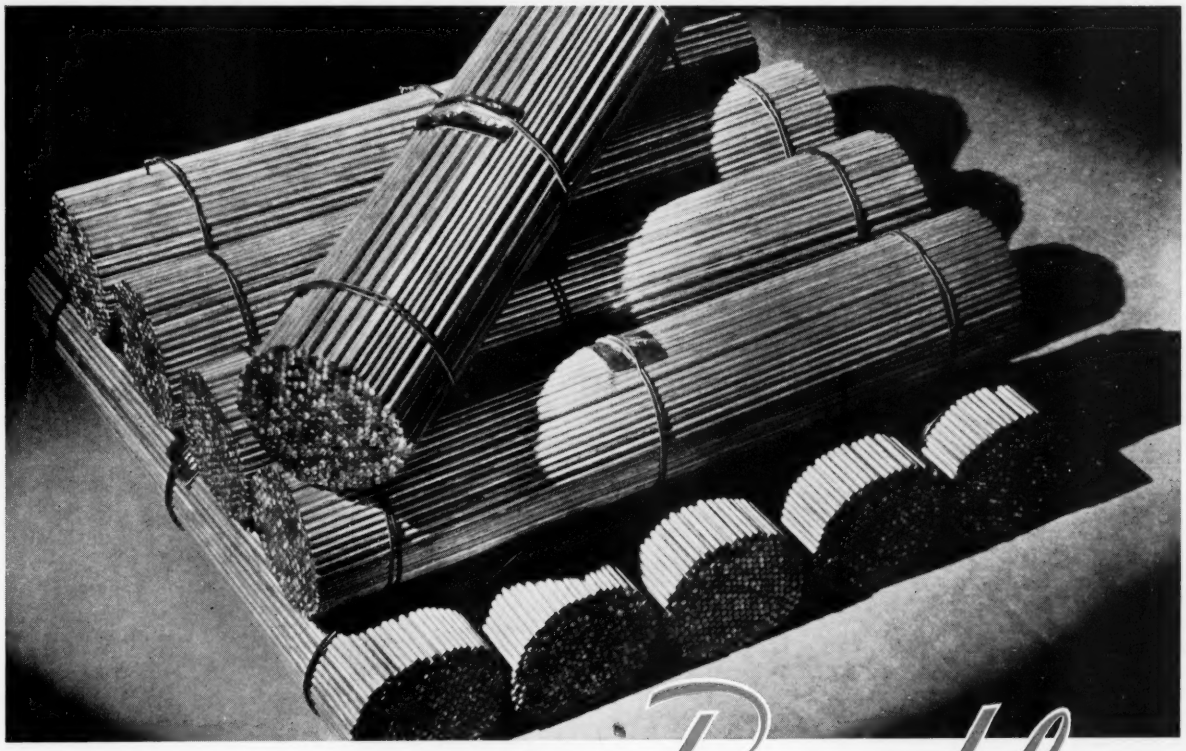
WIRE AND WIRE PRODUCTS

OCTOBER 1936



YOU CAN DEPEND ON *Republic*
TO MEET YOUR MOST EXACTING SPECIFICATIONS
FOR STRAIGHTENED AND CUT WIRE . . . . . .
FOR FULL PARTICULARS, WRITE DEPARTMENT WP, GIVING ANALYSIS, GAUGE, FINISH, LENGTH, ETC.

Republic Steel
CORPORATION
GENERAL OFFICES · · · CLEVELAND, OHIO

REPUBLIC STEEL
WIRE DIVISION . . . OFFICES AND PLANTS
7850 SOUTH CHICAGO AVENUE, CHICAGO, ILLINOIS

OFFICIAL PUBLICATION OF THE WIRE ASSOCIATION

BOLT WIRE
CHAIN WIRE
COAT & HAT HOOK WIRE
COLD HEADING WIRE
HINGE WIRE
MACHINE SCREW WIRE
PAIL BAIL WIRE
RIM WIRE
RIVET WIRE
SCREW STOCK WIRE
SPOKE WIRE
SPRING WIRE
WOOD SCREW WIRE
and seventeen other grades.

UNIFORMITY....

A shop-test of YOUNGSTOWN Manufacturers Wire will quickly prove its accurate adherence to specified diameter and quality of surface. At the same time you will find that Youngstown Wire gives you that consistent uniformity of working qualities so necessary to smoothly-operating production schedules. Bright wire can be furnished in all sizes from 18-gauge to $^{5}/_{8}$" in diameter; galvanized from 18-gauge to $^{5}/_{16}$"; coppered from 18-gauge to $^{3}/_{8}$".

THE YOUNGSTOWN SHEET AND TUBE COMPANY
Manufacturers of Carbon and Alloy Steels
GENERAL OFFICES: YOUNGSTOWN, OHIO

625

MANUFACTURER'S TRADE MARK YOUNGSTOWN WIRE

YOUNGSTOWN

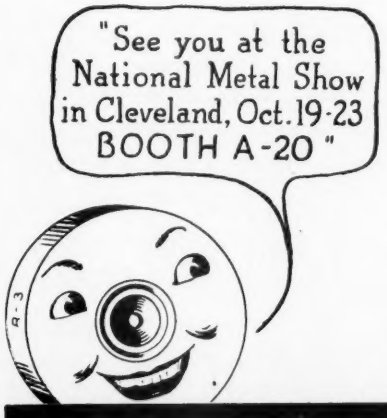
SHEETS • PLATES • TUBULAR PRODUCTS • CONDUIT • TIN PLATE • BARS • RODS • WIRE • NAILS • UNIONS • TIE PLATES AND SPIKES

Proper Care and Maintenance of CARBOLOY DIES is a Factor of Utmost Importance in Obtaining Maximum Savings

TOO much emphasis cannot be placed upon the importance of correct procedure in the care and maintenance of Carboloy cemented carbide dies. Careful planning and efficient handling in the die room and in the mill pay big dividends in added tonnage per hole size, better finish, and reduced die cost.

One of the most important factors in obtaining such economies, is the procedure followed in the die room.

Carboloy representatives will be glad to assist you in this or any phase of Carboloy die use.



CARBOLOY COMPANY, INC.
2985 Jefferson Avenue, Detroit, Michigan
Chicago Cleveland Newark Philadelphia Pittsburgh

Authorized Distributors:
Hartley Wire Die Co., Waterbury, Conn.
Canada: Canadian General Electric Co., Ltd., Toronto

CARBOLOY SERVICE

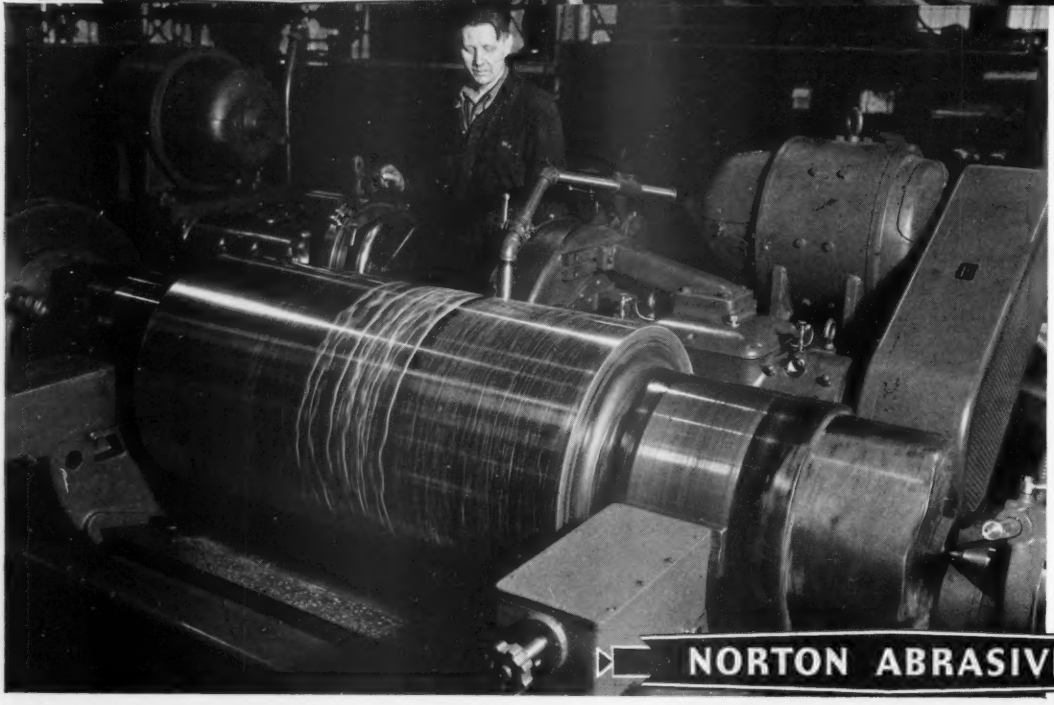
WIRE & WIRE PRODUCTS, Vol. 11, No. 10, October, 1936. Executive office, 17 East 42nd St., New York, N. Y. Published by the Quinn-Brown Publishing Corp., Richard E. Brown, President; R. S. Spengel, Secretary and Treasurer. Publication office, 13 West Church Street, Washington, N. J. Subscription price: U. S., $5.00; Canada, $5.00 per year, 50 cents per copy; Foreign, $7.50 per year. Entered as second class mail at the Post Office, Washington, N. J., under Act of March, 1879.

For the Finish You Want on Rolls of All Size and Kinds . . .

NORTON ROLL GRINDING WHEELS

BETTER and better finishes—that's what the wire industry keeps demanding on their rolls—highly polished, highly reflecting surfaces. And Norton engineers have kept pace—have developed grinding wheels that meet the most exacting requirements. Wheels made of the finest abrasive flours and either resinoid or shellac bonded.

NORTON ABRASIVES



NORTON ABRASIVES

NORTON COMPANY

●

Worcester, Mass.

New York, Chicago
Detroit, Cleveland
Philadelphia, Hartford
London, Paris
Wesseling, Germany
Corsico, Italy

W-566

For Increased Production and Better Quality Springs . . . depend on J & L Spring Wire

You step up production and get better quality springs when you standardize on J & L Spring Wire.

Your production is speeded up because J & L Spring Wire lends itself so readily to coiling, crimping, knotting and other forming operations incident to spring making.

You get uniform high quality springs when you use J & L Spring Wire because it has the resilience to provide just the right springiness, and the rugged stamina to hold that springiness indefinitely.

The high quality of J & L Spring Wire results from the use of special steel, exact heat-treating, accurate drawing and careful inspection to assure uniformity to specifications.

J & L Spring Wire is used by hundreds of manufacturers for a wide variety of springs because they know from experience that it gives them better springs at lower cost.

Specify J & L Spring Wire for your requirements. You, too, will find that it will speed up your production and give you better quality springs.

OTHER J & L PRODUCTS

FOR MANUFACTURING: Cold Heading Wire—Forging Steel—Jalcase Steel—Improved Bessemer Screw Steel—Shafting—Tubing—Tin Plate, Black Sheets, and Light Manufacturing Ternes, Tin Mill Sizes—a full line of S.A.E. Carbon Steels.

FOR CONSTRUCTION and MAINTENANCE: Structural Shapes, including Junior Beams and Lightweight Channels—Concrete Reinforcing Bars—Steel Pipe—Structural Shapes and Plates—Steel Piling—Fabricated Structural Work—Nails.

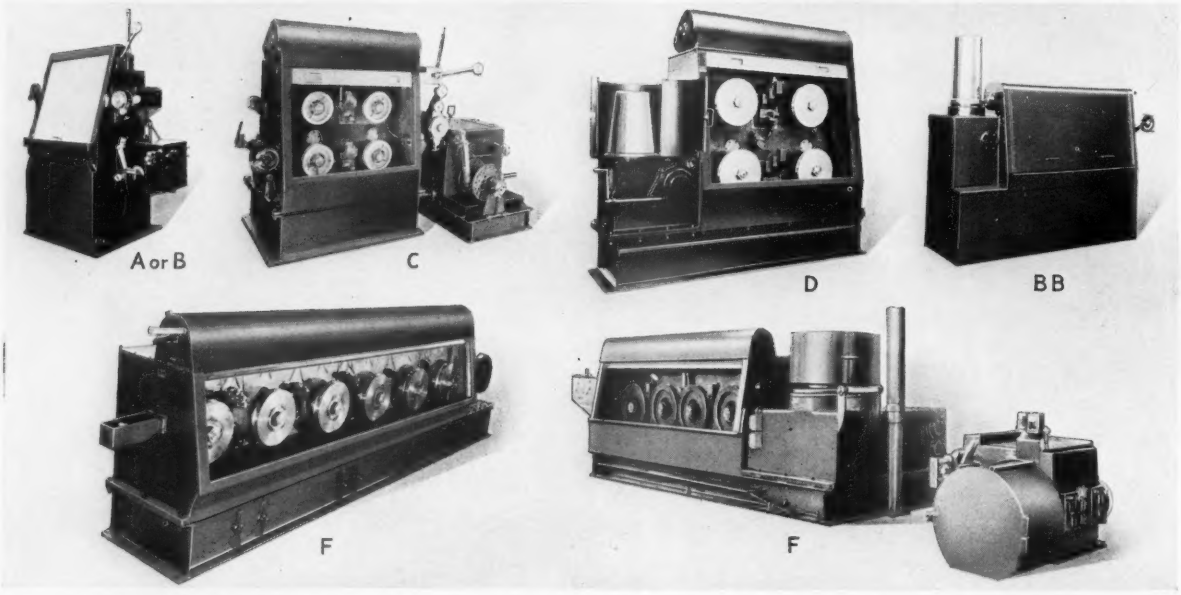
JONES & LAUGHLIN STEEL CORPORATION
AMERICAN IRON AND STEEL WORKS
JONES & LAUGHLIN BUILDING, PITTSBURGH, PENNSYLVANIA

Sales Offices: Atlanta Boston Buffalo Chicago Cincinnati Cleveland Dallas Denver Detroit Erie Houston Los Angeles Memphis Milwaukee Minneapolis New Orleans New York Philadelphia Pittsburgh Seattle St. Louis San Francisco Tulsa
Warehouses: CHICAGO CINCINNATI DETROIT MEMPHIS NEW ORLEANS NEW YORK (Long Island City)* PITTSBURGH
*Operated by National Bridge Works Division of Jones & Laughlin Steel Service, Inc.
Canadian Representatives: JONES & LAUGHLIN STEEL PRODUCTS COMPANY, Pittsburgh, Pa., U. S. A., and Toronto, Ont., Canada

J&L STEEL

ES

WIRE DRAWING EQUIPMENT



A complete line, minimum slip, wire drawing equipment built primarily for high speed wire drawing production. Liberal proportioning, anti-friction mounting, efficient power transmission, freedom from belts or chains, positive variable speed drive to spoolers to maintain uniform wire speed, accurate wire tension control at the point of spooling are a few of the features contributing to long life, efficient operation, economical production, clean and excellently wound quality wire.

Type of Machine	A	B	C	D	BB	F
With or without Spoolers	Yes	Yes	Yes	Yes	Yes	Yes
With or without Coiler	Yes	Yes	Yes	Yes	Yes	Yes
Size of finished wire B & S gauge	#34-#44	#26-34	#18-26	#12-22	#26-34	#2-#12
Number of Dies	16	16	12 or 13	13	13	5-7-9-11 or 13
Finished Wire Speed-FPM	5000	5000	4000	3500	2500 to 3500	2500 & 1000

High Speed Insulating Machines
For use with Paper — Cotton — Silk

Saturating and Finishing Equipment
For Weatherproof and Code Wire

Taping Machines for Cambric and Paper

Take-ups — Spoolers — Coilers

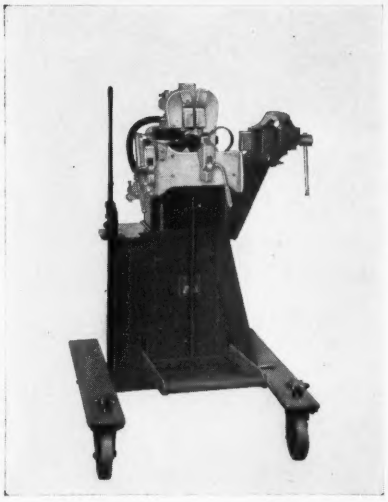
Complete Tinning Equipment

Other Equipment for Producing
Wire and Cable

ELEVATOR SUPPLIES COMPANY, Inc.

HOBOKEN, N. J.

MICROMETER PRECISION **MICRO-WELD** TRADE MARK REG. U. S. PAT. OFF.



Micro Model "J-5" and "J-6" With Dial Indicating Attachment. For Welding and Annealing High Carbon Wire.

IF you manufacture or fabricate wire, you can profit by using MICRO WELDERS.

✦ ✦ ✦

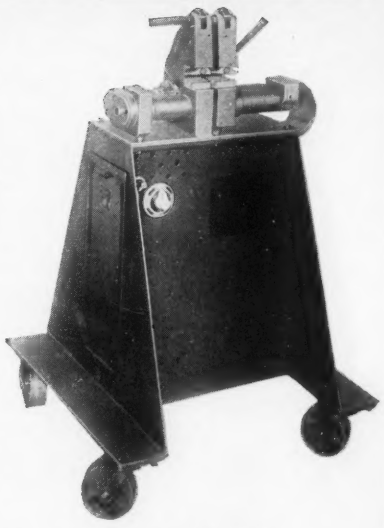
RUGGED construction that endures severe operating conditions assures definite results easier — quicker — over a longer period.

✦ ✦ ✦

SIMPLICITY of operation is your best guarantee of uniform consistent work.

✦ ✦ ✦

LOOK for the MICRO WELD symbol of proven success over the widest range of operations.



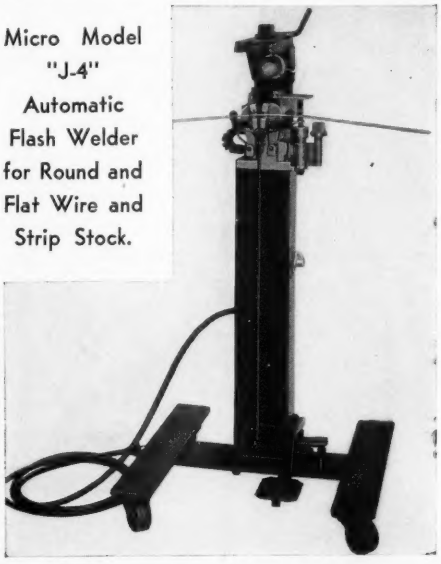
Micro Model "T" General Purpose Butt Welder for fast, accurate heavy-duty service.

Only MICRO-WELDERS are equipped with the patented MICRO-WELD adjustment dials for making precision welds faster.

Micrometer Precision **MICRO-WELD** Trade Mark Reg. U.S. Pat. Off.

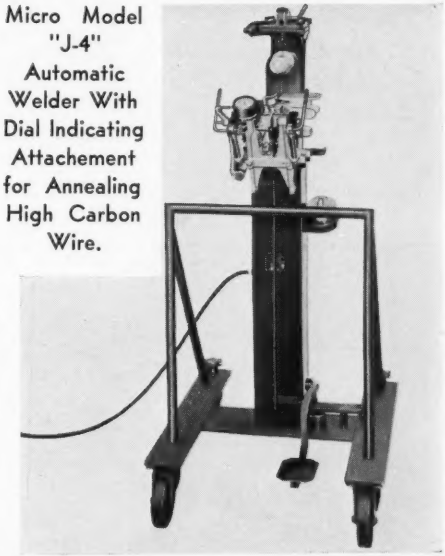
MICRO-WELDERS with dial indicating annealing attachments are now available for high carbon wire.

Micro Model "J-4" Automatic Flash Welder for Round and Flat Wire and Strip Stock.



There is positive control of annealing temperature and already hundreds of these special MICRO-WELDERS are proving their dependability and satisfactory performance with leading manufacturers.

Micro Model "J-4" Automatic Welder With Dial Indicating Attachement for Annealing High Carbon Wire.



Ask us about your welding problems and we'll tell you what MICRO can do for you.

MICRO PRODUCTS COMPANY

20 NORTH WACKER DRIVE, CHICAGO, ILL.

Telephone State 7468 General Office and Factory, Peoria, Ills.

"HUDCO" PRODUCTS...
Specially Processed Copper Wire...

▲ ▲ ▲ Electrolytic and Oxygen Free ▲ ▲ ▲

WIRE---
ESPECIALLY MADE FOR METALLIZING

Pure Lead
Lead Alloy
Pure Zinc
Zinc Alloy
Copper
Tin
High Brass
Low Brass
Solder Wire
Cadmium
Nickel Silver (10%, 18%, 30%)
Aluminum
Monel Metal
Phosphor Bronze
Pure Nickel
Commercial Bronze

"HUDCO" High Conductivity Electric Wire

✦ ✦ ✦

BRUSH WIRES, CRIMP and STRAIGHT

Brass, Steel, Nickel Silver, Copper and Phosphor Bronze

✦ ✦ ✦

TINSEL LAHNS

Silver Plated Copper, False Gold and Copper

✦ ✦ ✦

METALLIC FIBRE FOR PACKING PURPOSES

Copper, Bronze, Zinc, Lead and Aluminum

FINE BARE WIRES

High Brass
Low Brass
Zinc 99.99+ and High Tensile Zinc
Commercial Bronze
Phosphor Bronze
Pure Tin
Lead
Antimonial Lead
Cadmium
Nickel Silver, 10%, 18% and 30%
Silver Plated Copper
False Gold and Special Brass and Bronze Alloys to Specification

---

Winco PRODUCTS

Leakproof Enameled Wire

and enameled wires in all Standard and Special Covering ▲ ▲ ▲
Made to meet the most exacting requirements ▲ ▲ ▲
THE WINSTED DIVISION OF HUDSON WIRE COMPANY, WINSTED, CONN.

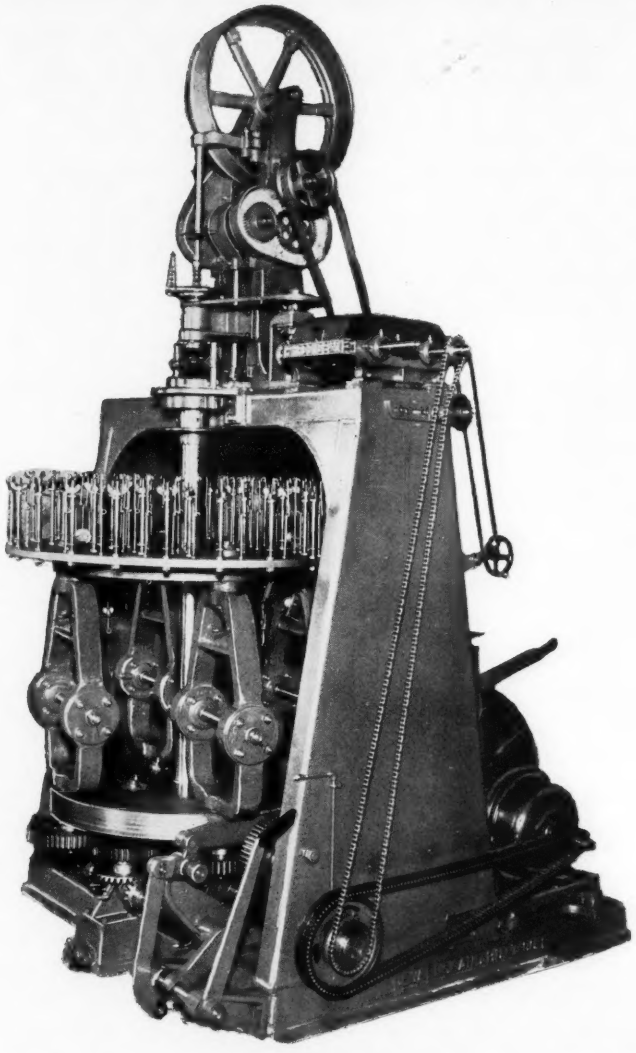
We can serve you quickly and economically.
Send in your specifications for a quotation.

HUDSON WIRE COMPANY

Ossining, N. Y.

Estab. 1902 — Successors ROYLE & AKIN — Estab. 1902

NEW VARIABLE PLANETARY CABLE MACHINE



This CABLING MACHINE was developed to manufacture cords with two, three, and four conductors that require a smooth outer surface and must lay without kinking.

The machine is provided with steel cradles for supporting four steel reels mounted on ball bearings; also with fifty-two spindles for cotton fillers, and a cotton winder head with storage capacity for eight extra cops of yarn for binder; a 24″ diameter capstan; and a 36″ diameter reel take-up with automatic traverse motion.

The machine is driven with a 10-horse power motor which drives the rotor in either direction at 205 r. p. m., with change gears for varying the amount of back turn of the individual conductors. Change gears are provided to give lays from ⅜″ to 6½″.

A complete description with specifications and price will be supplied upon request.

NEW ENGLAND BUTT COMPANY

Chicago Office
20 NORTH WACKER DRIVE

Main Office and Plant
PROVIDENCE, R. I.

Registry of Used Wire Machinery

The Dunscomb Plan

WE do not buy, sell, or stock equipment. We function only as a registry bureau to arrange the sale of used wire equipment direct from wire mill to wire mill. Equipment offered through us is listed (at no charge) with as much detail as would assure an inquirer that the item is actually adapted or easily adaptable to his specific need. We aim, without putting too much of a burden on the owner, to carry in our files enough information to save the time of all parties to a transaction.

✦ ✦ ✦

OUR usual procedure is to put buyer and seller into contact and let them work out whatever deal is satisfactory. If a price is given us when the item is listed, we generally pass it on to the inquirer as an estimate. When a deal is closed we take from the SELLER 10% of the selling price as our commission.

✦ ✦ ✦

MANY of our listed items and wants are advertised monthly in Wire and Wire Products, which has practically complete coverage in the wire field. Seeing, as we do, both sides of the picture, we often match up wants and offerings without advertising, or by direct mail, and as our operations expand this is becoming increasingly easy. We cover this field so effectively that if a sale is made after we have published a listing we are bound to believe that it resulted from our efforts, whether directly traceable or not, and we require that our clients take the same view.

✦ ✦ ✦

WE do not ordinarily inspect or appraise items offered through our listings but we have access to thoroughly competent advice and can arrange for such service on request.

✦ ✦ ✦

THIS business all passes, ultimately, over one desk, and our files are private. This makes it easy for us to conduct a negotiation with any degree of secrecy or discretion that a client may specify.

✦ ✦ ✦

If You Have Used or Surplus Machinery For Sale We Can Help You.

No Charge For Listing.

See List on Page Following

APPRAISALS ✦ ✦ ✦ STEEL AND NON-FERROUS ✦ ✦ ✦ INSPECTIONS

FOR DETAILS WRITE

Dunscomb Associates

BOX 320, C/O WIRE AND WIRE PRODUCTS — 17 EAST 42nd ST., NEW YORK, N. Y.

REGISTRY OF USED WIRE MILL MACHINERY

Registry of Used Wire Machinery

We Offer—Subject to Prior Sale—The Following Used Wire Mill Machinery

Waterbury stand spooler for fine wire.

No. 348
Five-block rod bench with gear drive and motor, 26″ and 22″ blocks.

No. 400
Twenty head enameling machine complete, capacity down to .001.

No. 401
Eight head spooler, capacity 200 lb. spools, motor driven.

No. 402
Hayes electric furnaces, automatic control, with 32 head spooler, for fine wire.

No. 403
Waterbury straight roll fine wire machines, motor and belt drive.

No. 432
24 block intermediate frame with 16″ blocks, reducer, and pulley drive.

No. 441
Vertical Olsen tensile testing machines, 10,000

No. 445
Five-head S. & H. florist wire machine.

No. 456
Tinning equipment:
10 and 20 block fine wire units, 8″ block.
8 block unit for 16″ and 22″ blocks.

No. 459
Shuster straightening and cutting machine for ⅝ round.

No. 460
120 National Nail machines, 2D to 60 D.

No. 461
15 Lambert Cut Nail machines 4 D to 10 D.

No. 464
9 Emery Barb Wire Machines, 2 and 4 point.

No. 465
Am. Hard Rubber Acid Pump, Model B-244, 2″ x 4″.

No. 469
Two and four blocks heavy rod benches with motors and drives.

No. 470
24-carrier single deck textile 4″ braiders.

WE HAVE BUYERS FOR THE FOLLOWING

No. 448
7-wire planetary closing machine for 24″ reels.

No. 457
Diamond die polishing machines
1 for .080
2 for .050
3 for .025

No. 458
Equipment for manufacturing Tungsten and Molybdenum wire, press and dies, slug treating, swaging, drawing and spooling machines.

Roll flattener for strips ⅛″ thick up to 20″ wide.
Machine for round edging narrow flats.

No. 472
Turks heads, 3 U, 4 U, 5 U, without rolls.

No. 473
Electro galvanizing machine for screen cloth.

No. 474
Calender rolls for Wire Cloth 8 to 12″ dia. rolls, 36″ length.

No. 475
Bull blocks for ⅝″ steel.

No. 476
Heavy rod bench 3 to 5 blocks all above floor, preferably Morgan.

No. 477
Small Watson Stillman solder extrusion press.

No. 478
Larmuth type stranding machines, 7 and 12 spool, equivalent of N. E. Butt S-25-29-30.

No. 479
Single and double cotton serving machines.

No. 480
24-spindle cotton winding equipment, 4 and 6 inch traverse.

No. 481
3-head strip machines, 6″ and 9″ cutter size.

No. 482
Wax saturating and finishing tanks, small and medium, gas heated drum type.

No. 483
Stringing machines, one for rods up to 3-8, one for No. 4 to No. 12 wire.

No. 484
Shuster machine for ¼″ maximum.

No. 485
Rigid frame stranders, 25 lb. spools, 37 to 137 wires.

No. 486
Planetary closers, 3 or 4 wire, 48″ to 54″ reels.

No. 487
Concentric taping heads, 18″ to 24″ discs.

No. 488
Wardwell braiders, 16 and 24 carrier.

No. 489
60″ and 84″ Rubber mills.

No. 490
Vulcanizers, 72″ x 15 ft. horizontal, 84″ x 8 ft. vertical.

No. 491
Vulcanizer reels 50″ to 60″ diam. x 5 to 8 ft.

No. 492
Wire measuring machines.

No. 493
Scott tensile machines, 12 and 100 lbs.

No. 494
Platform scales, 250, 500, and 1000 lbs.

Dunscomb Associates

BOX 320, C/O WIRE AND WIRE PRODUCTS — 17 EAST 42nd ST., NEW YORK, N. Y.

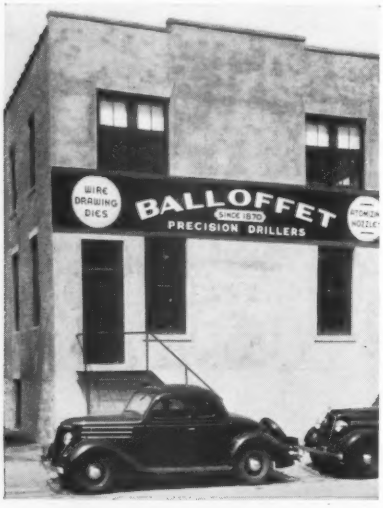
REGISTRY OF USED WIRE MILL MACHINERY

BALLOFFET *Announces . . .*

1 8 7 0 — 1 9 3 6

INCREASED FACILITIES

To satisfy the constantly increasing demand for its products, Balloffet has been compelled to enlarge its manufacturing facilities. The new building at Guttenburgh, N. J. is just completed. New machinery, greater storage space, increased facilities, all mean better and quicker service to our customers . . . but the same skilled mechanics and die makers have moved with us, thus insuring the same precision and accuracy that have always characterized Balloffet products. The trade is cordially invited to visit us at our new quarters. We are now ready to meet any demands you may place upon us. Just let us know your requirements.



New Balloffet Building, Guttenburgh, N. J., occupying over 5,000 square feet of space.

BALLOFFET

The Quality Diamond Dies

BALLOFFET DIAMOND WIRE DIES CO., INC.

45-51 ADAMS ST., GUTTENBURGH, N. J.

Hubbard Spool Company

Extends Greetings to the

Members of the

Wire Association

Here's to a Successful

Meeting!

Hubbard Spool Company

1622 Carroll Avenue

Chicago, Ill.

TELEPHONE SEELEY 4554

FARREL
REG. U.S. PAT. OFF.

ROLLING MILL MACHINERY

ROLLING MILLS—For non-ferrous metals, foils and cold strip steel. Complete rod mills from furnace to coilers

ROLLS—All sizes for various purposes. Chilled Iron, Special Alloy Iron, Steel

UNIVERSAL MILL SPINDLES

ROD MILL TABLES AND MANIPULATING EQUIPMENT

LEAD PRESSES FOR PIPE OR ROD

ROLL GRINDING MACHINES

ROLL CALIPERS

CINDER CRUSHERS

GEARS

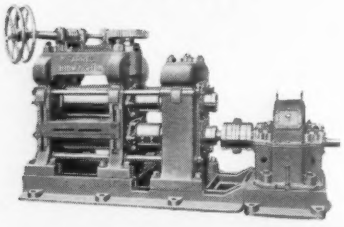
MILL PINIONS

PINION STANDS

DRIVES UP TO 10,000 H. P.

FLEXIBLE COUPLINGS

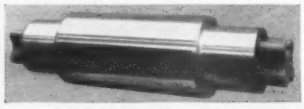
ROLLING MILLS



Farrel Rolling Mills are built in a wide range of sizes, designed for any specific purpose and constructed with the greatest care to insure precision. Improved design and construction provide many advanced features which bring about higher operating efficiency, increased output, lower power consumption, minimum labor and maintenance costs and improved quality products.

Our engineers will be glad to explain in detail the design features and operating advantages of Farrel Rolling Mills as applied to your particular conditions. A conference involves no obligation and may develop data relating to plant layout, operation, costs, etc., which will be helpful in making comparisons with present equipment and methods and in the selection of new equipment for greater operating efficiency and economy.

ROLLS



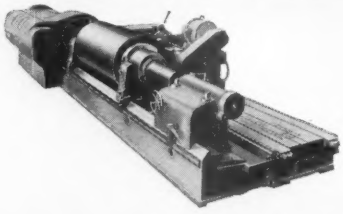
Over seventy-five years' experience in designing and manufacturing rolls for a broad variety of uses, unexcelled plant facilities, modern equipment, skilled technicians in metallurgy and engineering, founders and machinists trained in specialized roll manufacture, make an effective combination for producing rolls of superior quality, precision and durability.

Farrel Rolls are made in several grades, including Cupola and Electric Furnace Chilled and Alloy Iron, Heat-Treated Farrel Ni-Hard, and Steel.

Farrel Ni-Hard Rolls combine a hardness of 85 to 90 with high strength and a flawless surface. They are ideal for high finish sheets as they produce a higher quality finish, their life is longer and cost per ton of output is lower.

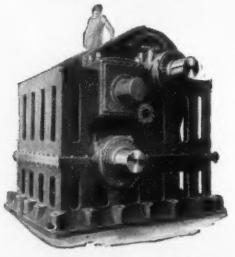
ROLL GRINDERS

Farrel Heavy Duty Roll Grinders are designed for better, faster and cheaper grinding to the extreme limits of accuracy required by modern rolling mill practice. They are built in six standard sizes to handle rolls up to maximum diameters of 24″, 28″, 36″, 44″, 52″ and 60″ and lengths from 8′0″ to 26′0″ between centers.



DESIGN FEATURES: Individual motor drive for each unit with centralized control at operator's station. Crowning device produces mathematically correct crown or concavity—very easily and quickly set. Smooth, vibrationless work drive through multiple V-belt driven headstock. Improved spindle and wheel head design. Carriage driven by reversing motor through cut double helical gears and worm and rack. Inverted "V" ways, flood lubricated. Dead centers in both headstock and footstock. Heavy, rugged construction imparts stability. Combination of all features assures high quality of work with maximum production.

GEAR DRIVES



Farrel Heavy Duty Mill drives are designed by engineers with a thorough understanding of the conditions imposed by the higher speeds and heavier loads encountered in modern rolling mill operation.

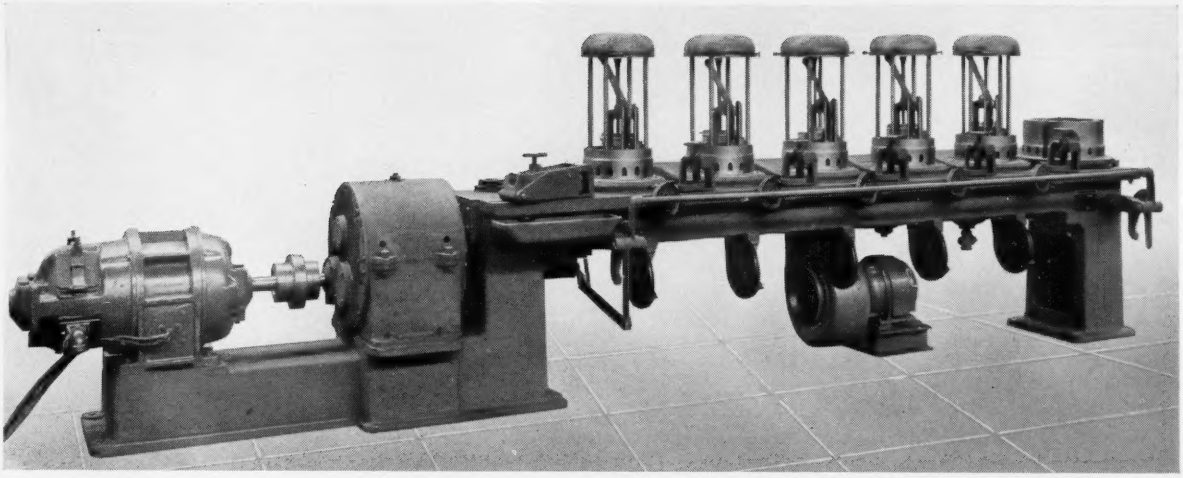
The drives are scientifically proportioned, with large factors of safety, and are built of carefully selected materials, designed to provide maximum strength and rigidity. The continuous tooth herringbone gears are accurately generated by the Sykes process. Advanced features of design assure high efficiency, smooth, quiet operation, trouble-free service and long life.

Available in single, double and multiple reduction units, for high or low speeds, and any power up to 10,000 H. P.

FARREL - BIRMINGHAM COMPANY, INC.

38 Main St. Ansonia, Conn. — 327 Vulcan St., Buffalo, N. Y.

NEW YORK, PITTSBURGH, AKRON, CHICAGO, LOS ANGELES



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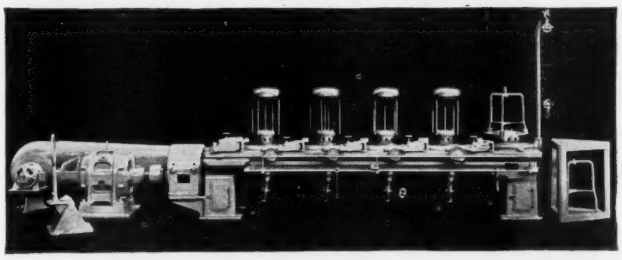

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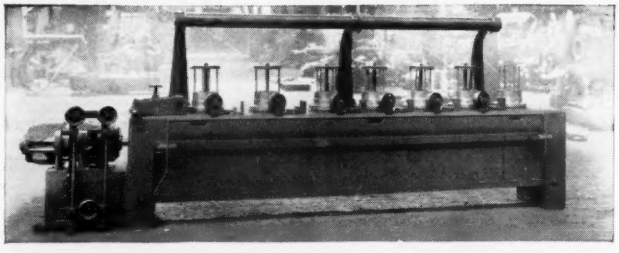

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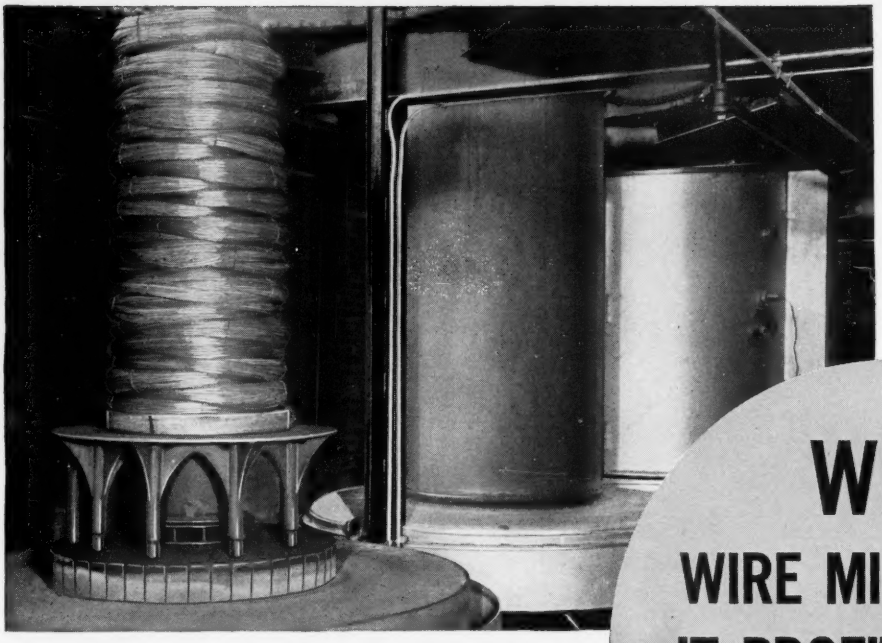

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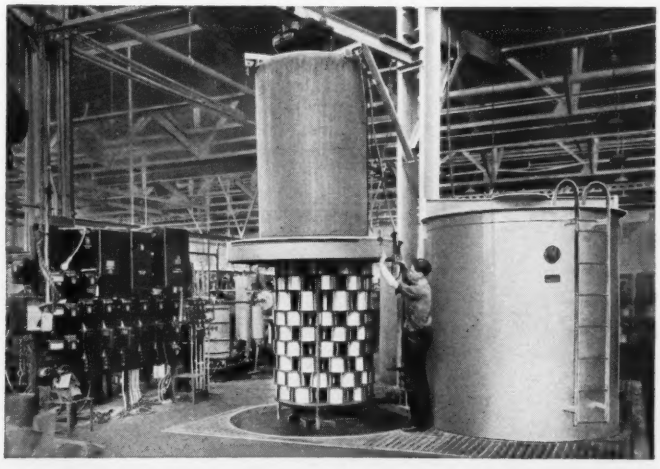

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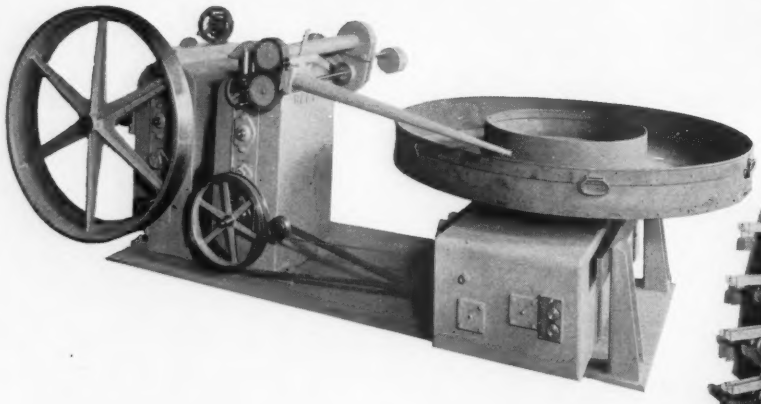

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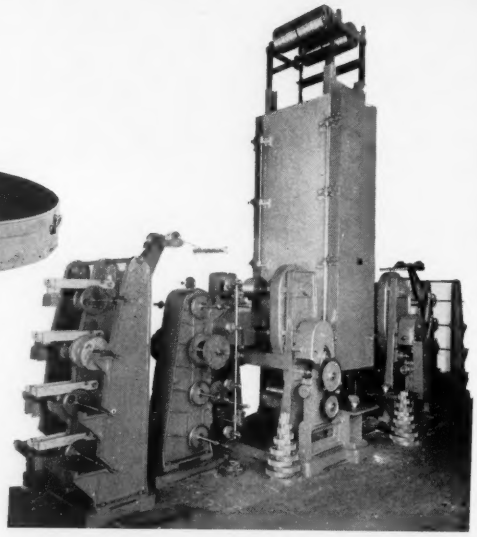

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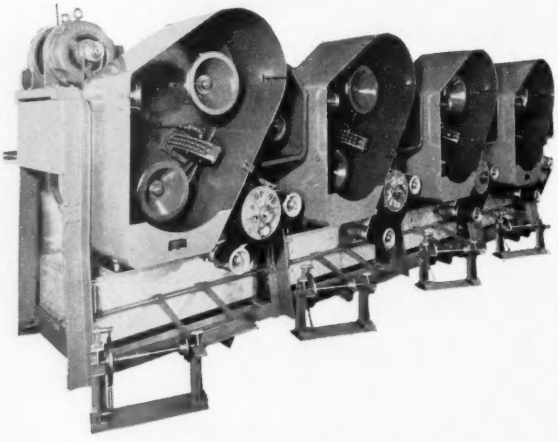

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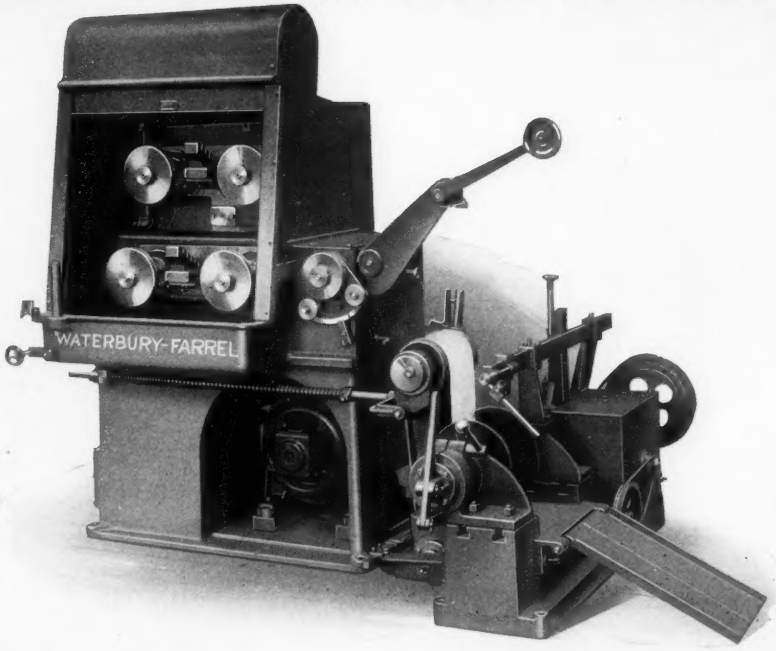

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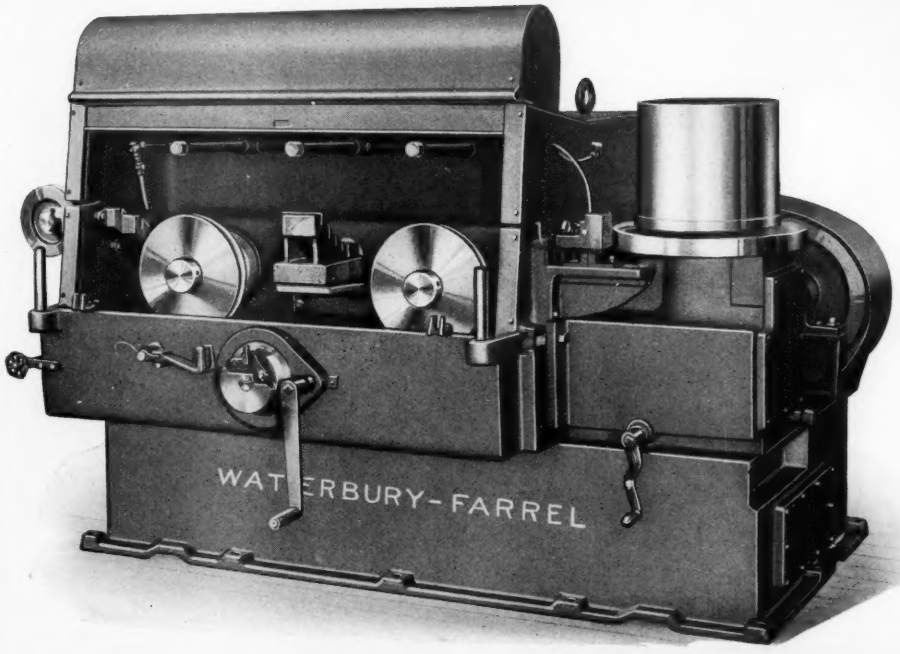

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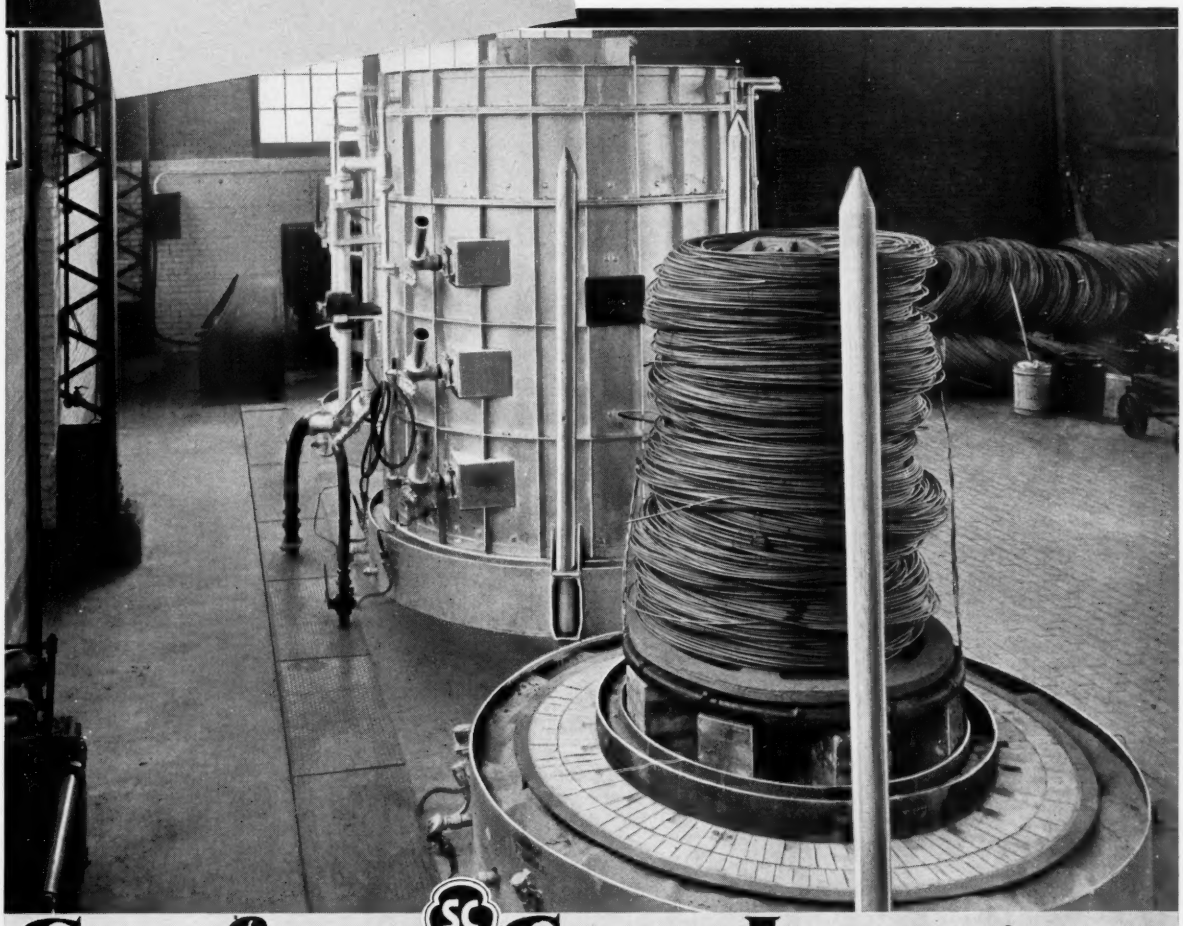

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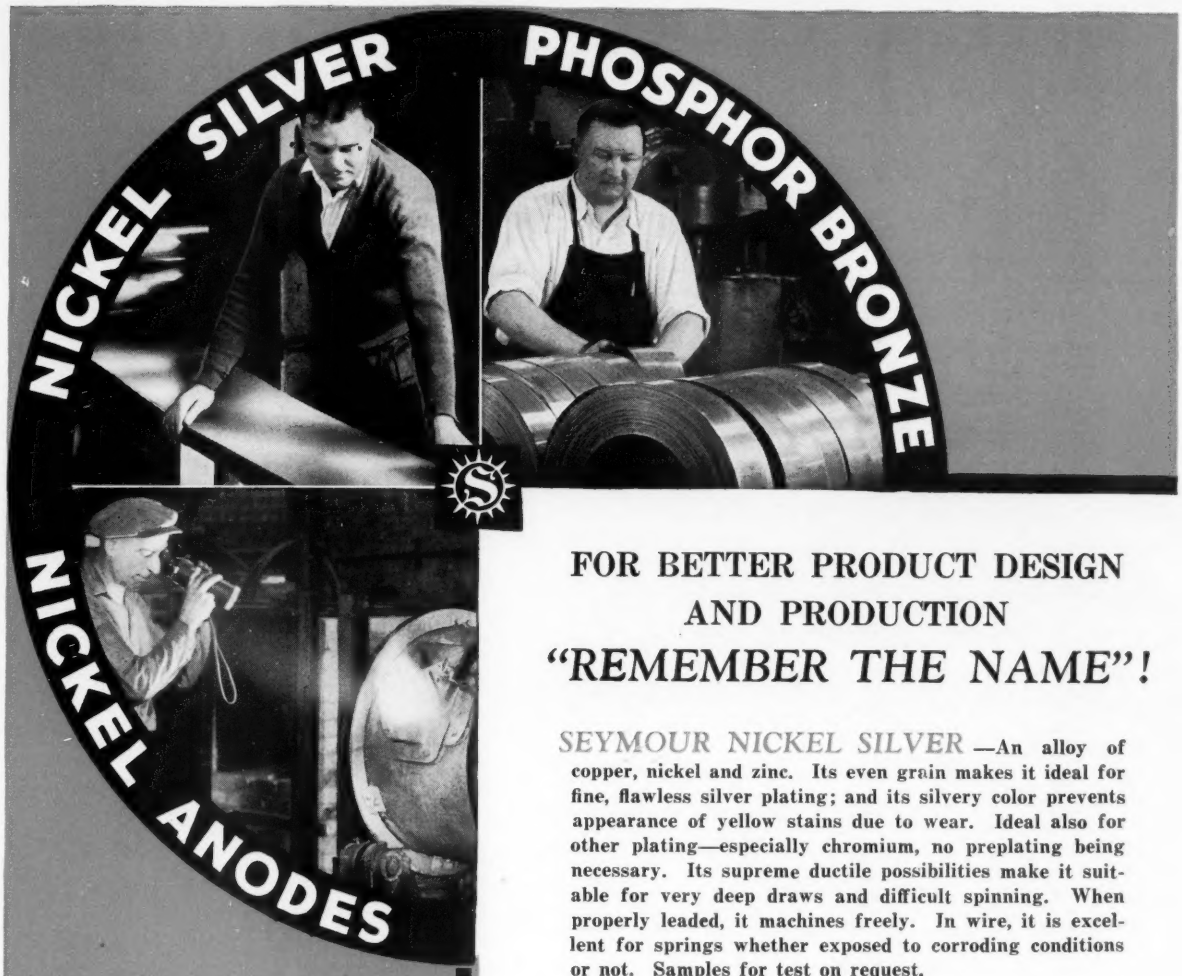

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A monthly publication devoted to the production of Wire, Rod and Strip Wire Products and Insulated Wire and Cable

DRAWING—ROLLING—EXTRUDING—FORMING—FABRICATING

Vol. 11 October 1936 No. 10

Designated as

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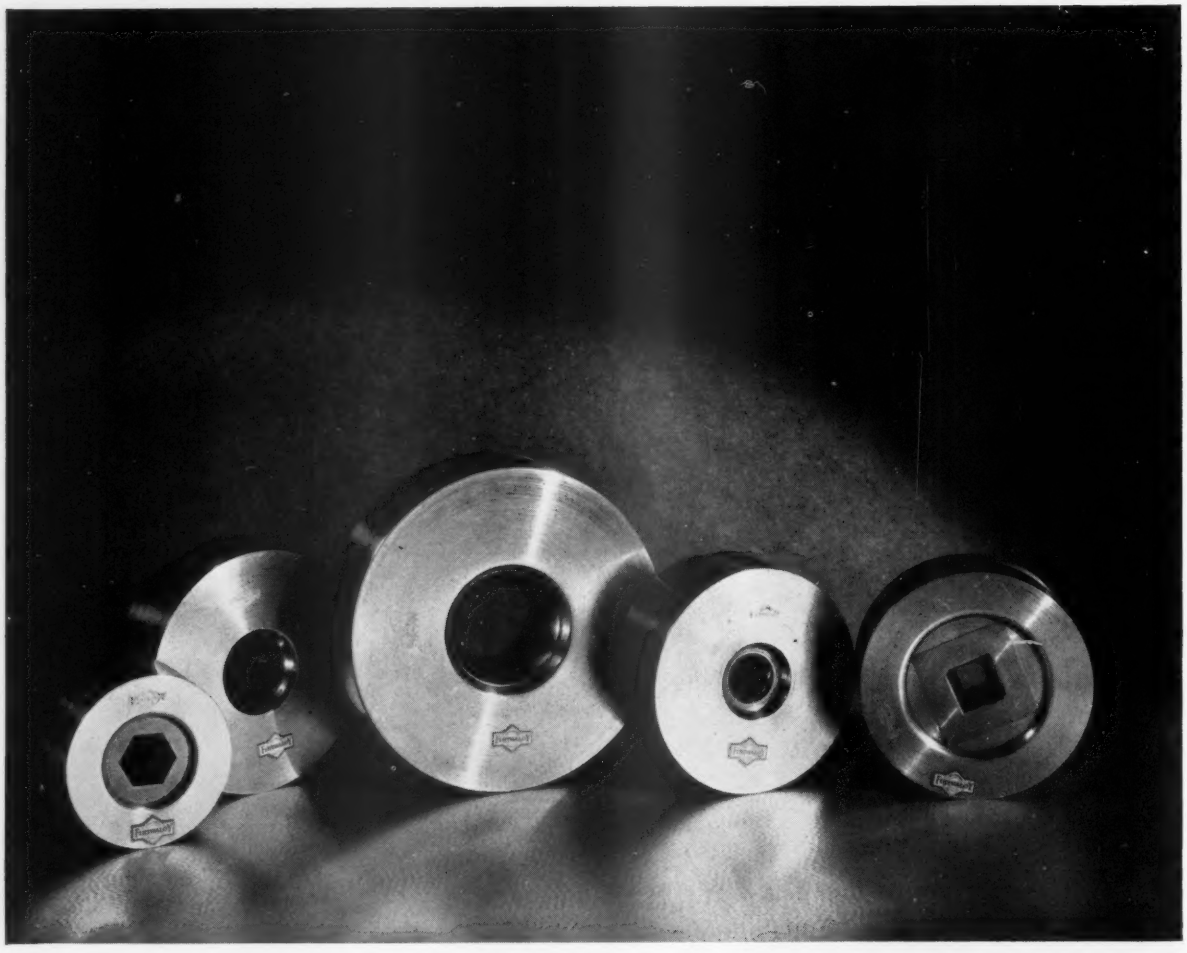

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DRAWING --- ROLLING--- EXTRUDING --- FORMING --- FABRICATING

Vol. 11 OCTOBER 1936 No. 10

Plastic Deformation In Wire Drawing

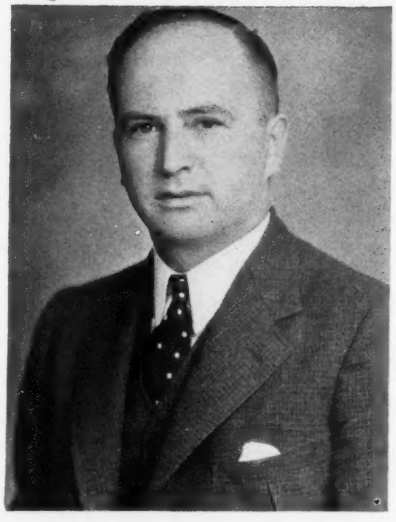
By B. L. McCarthy, Metallurgist,
Wickwire Spencer Steel Co., Buffalo, N. Y.

This paper is intended to present a picture of what occurs when metal is cold worked, and the various factors that interfere with the uniform distribution of cold working strains. While most of the specific examples relate to the drawing of steel wire, the same general principles can be applied to the non-ferrous metals and alloys from which wire may be drawn.

ALTHOUGH the cold working of metal is one of man's oldest arts, it is only in recent years that it has approached some semblance of being scientifically directed. Even today much of the wire being manufactured is produced by experience and cut-and-try methods, rather than by the application of scientific knowledge. Most of the literature available on wire drawing, deals with effects rather than causes and while it is true that we are seeking results rather than reasons, the demands for quality being made today makes it imperative that we have a better knowledge of the reasons so that the desired results can be obtained more easily and efficiently.

✦ ✦ ✦

THIS paper is presented with the thought of placing before you some of the fundamental principles of wire drawing, in the hope that it may serve to promote your interest in the scientific aspects of the problems that confront us. No longer can we afford the old cut-and-try methods, the reasons for failure and the corrective measures to employ must be understood to cope with the ever increasing demands for high quality.



BENJAMIN LEWIS McCARTHY

Born in Lockport, New York, in 1895. In 1913 was employed as Assistant Chemist by Simonds Saw & Steel Co. In 1916 was employed by Wickwire Steel Co., now known as Wickwire Spencer Steel Co., as Assistant Chief Chemist. Three years later was promoted to Chief Chemist and Metallurgist. Now in charge of the Chemical and Metallurgical Laboratories and directs research and special investigation into the Chemistry and Metallurgy of steel, steel wire and wire products. Member of the Wire Association, The American Society for Testing Materials, and the American Society for Metals. Awarded the Wire Association Medal for the most meritorious paper on wire manufacture or fabrication during the year 1935.

Hardness Produced by Cold Working

NO discussion of the scientific side of wire drawing would be complete without some attempt to explain the phenomenon of cold working hardness. In using the term hardness in this connection it should be remembered that it is used as an indication of resistance to deformation rather than that of the scratch hardness type, associated with the diamond, or the change in hardness of steel resulting from a change in chemical composition.

✦ ✦ ✦

MANY theories have been advanced to account for the hardening of metal on cold working, the most outstanding of which are the amorphous metal theory of hardening set forth by Bielby[1]* and the Slip Interference Theory of Jefferies and Archer[2]. Bielby contended that cold working results in a crystal fragmentation, which produces particles too small to form cubes. Because of the non-crystalline nature of this material it is said to be amorphous and produces the hardening effect. As the amount of cold work is increased, the amount of this amorphous ma-

*Refer to list of references at end.

terial increases and likewise the hardness.

✦ ✦ ✦

IN the author's opinion, the Slip Interference Theory of hardness offers the most satisfactory explanation. This theory is based on block movements of cubic crystals all in the same plane along planes of easiest slip. Inasmuch as the forces which tend to hold the metal together are the attractive and repulsive forces of the atoms, these block movements or slips strain these forces within the limits of atomic cohesion. Because of the rigidity of the metal the strain persists until heat is applied. The slips or block movements which take place are limited to the number of crystals in a given grain. As soon as a grain boundary is encountered, both the amorphous metal present at the grain boundary and the difference in orientation, between grains, offer interference to slip. As cold work is continued the movement first associated with planes of easiest slip continued along planes which offer more resistance to slip. Each movement of blocks of crystal units influences the ease of slip along other slip planes. In this manner the resistance to deformation of a metal is increased by cold working.

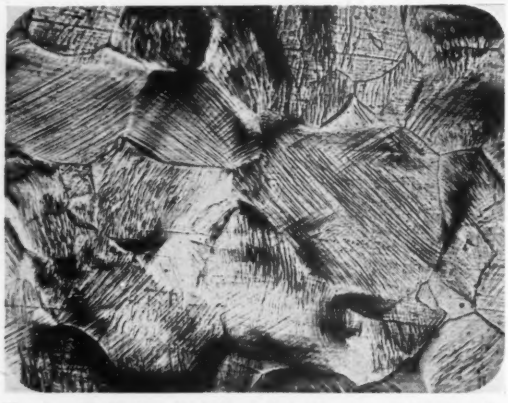


Fig. 1. .05 Carbon Steel Treated to Promote Grain Growth, Polished, Etched, Strained to Show Slip and Photographed — 200 X.

✦ ✦ ✦ ✦ ✦ ✦

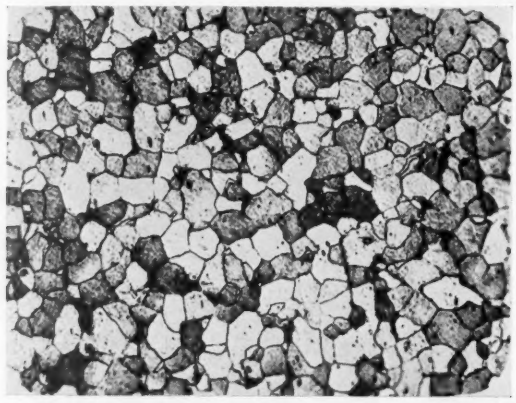


Fig. 2. Low Carbon Steel Etched to Show Grain Orientation — 200 X.

✦ ✦ ✦ ✦ ✦ ✦

✦ ✦ ✦

THAT this slippage or block movement actually occurs can be seen from an examination of Figure 1. Note the numerous slips that have occurred and the manner in which the direction of slip changes from grain to grain. As cold working is continued, slips in opposite direction than the original ones begin to develop, this is also shown in Figure 1 and a change in orientation takes place which finally results in the elimination of slip planes. Excessive straining of the metal beyond this point will result in fracture due to the absence of slip planes and the breaking of atomic cohesion.

✦ ✦ ✦

THE orientation of grains referred to above is based on the plane of the cube faces and can be seen on polished and etched specimens under the microscope. In Figure 2 is shown a sample of low carbon steel which has been etched to bring out grain orientation. Note the difference in etching attack on different grains, this is due to the angle at which the planes of the cubes meet the plane of the polished surface of the specimen. While it is more difficult to observe because of the etching characteristics, the same is true of high carbon steels.

✦ ✦ ✦

WE now have before us a picture of plasticity depending on ease of slip of the cubic crystals of which the metal is composed, factors which interfere with slip will, by setting up increased resistance to further slip, increase the hardness. In metals which contain areas of varying degrees of hardness, a given amount of deformation will first be effective in the softer areas. A difference in the plasticity of different areas will produce uneven strain distribution. If the metal contains areas which offer considerable resistance to deformation, it is possible to destroy cohesion in the more ductile areas. The size of the grains play an important part in the amount of hardness developed, for as has already been shown the direction of slip changes with the orientation of the grains. This limits the block movements of cubes and increases the hardening.

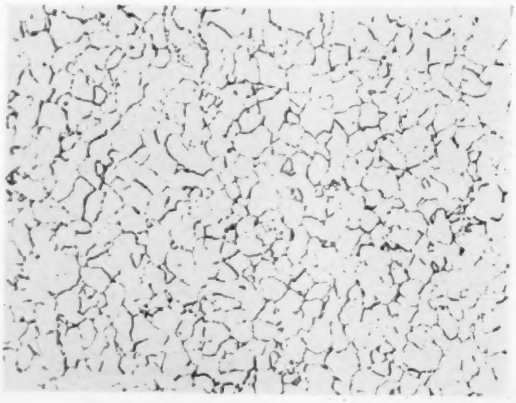


Fig. 3. Electrolytic Iron Heated to 1700°F and Cooled in Air — 200 X.

✦ ✦ ✦ ✦ ✦ ✦

✦ ✦ ✦

Metal From Which Wire is Drawn

WIRE is drawn from two types of metals:

1st—Pure metals and solid solutions

2nd—Aggregates

✦ ✦ ✦

BY pure metals and solid solutions is meant, metals

to which no alloying elements have been added and metals which contain alloys completely soluble, one in the other, in the solid state. The ferrite of commercial steels which contain manganese, silicon and phosphorus in solution and the austenitic alloys such as the chromium, nickel, austenitic steels, are examples of solid solutions from which wire is drawn.

✦ ✦ ✦

IN Figure 3 is shown the structure of pure iron.

✦ ✦ ✦

IN Figure 4 is shown the structure of a nickel chromium steel of the 18% chromium—8% nickel variety.

✦ ✦ ✦

BOTH pure metals and solid solutions depend on the size of the grains and the inherent plasticity of the metal for the amount of hardening produced on cold working. Pure metals are more plastic than solid solutions, this has been explained as follows:[3]

Solid solutions are harder than pure solvent metals because slip is interfered with by the greater attraction between unlike than between like atoms and by the roughening of slip planes due to solute atoms of different effective size than the solvent atoms.

✦ ✦ ✦

THE increase in stiffness associated with Bessemer stock over that encountered in Basic Open Hearth steel may be employed as an example of the effect of an additional element to a pure metal. In this case the added phosphorus results in an interference of slip and increases the resistance of the metal to deformation in line with the above explanation. Additions of manganese, chromium, nickel, etc., to iron and zinc to copper, etc., are similar examples. The above references applying to both ferrous and non-ferrous metals and alloys.

✦ ✦ ✦

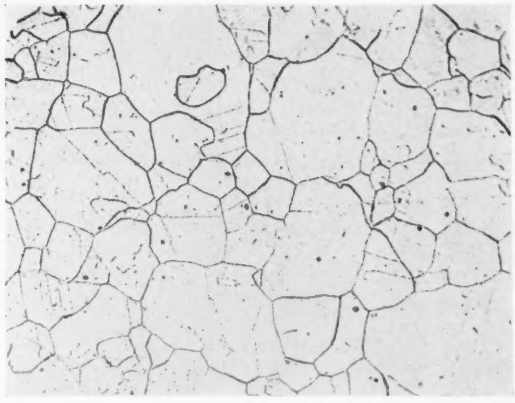


Fig. 4. Chromium-Nickel Steel Quenched in Water from 1850°F — 200 X. ✦ ✦ ✦ ✦ ✦ ✦

THE terms "aggregates" is used in this instance to signify a combination of dissimilar substances such as pure metals containing intermetallic compounds. Copper containing copper oxide and steel which consists of a solid solution of iron, manganese, etc., but in which there is iron manganese carbides not in solution, are examples of this type of metal. The precipitated constituent iron carbide may be in the form of rounded spheroids of cementite, of varying degrees of fineness, or combined with ferrite to form the structure known as pearlite. In Figure 5 is shown a structure containing spheroidized cementite, while in Figure 6 is shown the structure of pearlite. In one case we have iron carbide (cementite) free, in the other it is combined with ferrite in the form of alternate plates of each.

✦ ✦ ✦

Wire Quality

THE term quality in wire may be used to designate a number of properties and, for each individual application would be difficult to explain. For one purpose an extremely stiff wire may be desired and no attention paid to ductility. In this case the degree of stiffness would determine the quality. In another, extreme softness may be desired with no regard to strength the degree of softness would be used as an indication of quality in this instance. Most of these requirements can be taken care of in the usual line of wire mill routine. If extreme softness is required the annealing process is employed followed by a light draft if bright soft wire is desired, or shipped as annealed wire. Stiffness can be controlled in various ways, by heavy drafting, by altering the chemical composition or by both. As stated above, the presence of an increased amount of another element such as phosphorus, when Bessemer steel is employed will greatly increase the stiffness. While it is true that the tensile strength may be used to a large extent as an indication of stiffness, this is not always the case for it is possible to produce two wires of the same tensile strength but with varying degrees of stiffness.

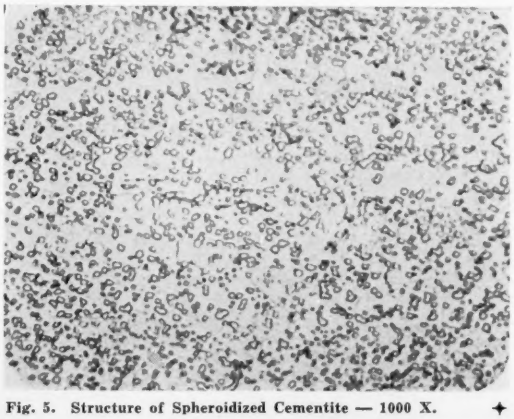


Fig. 5. Structure of Spheroidized Cementite — 1000 X. ✦

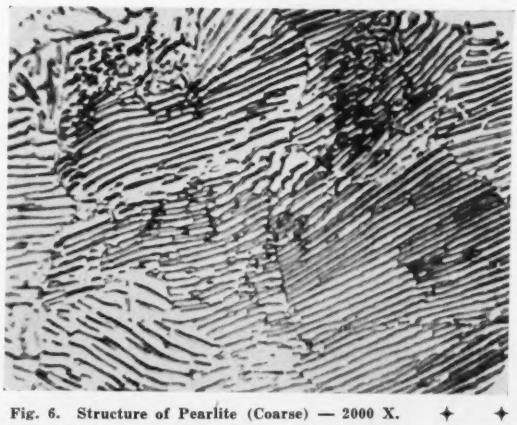


Fig. 6. Structure of Pearlite (Coarse) — 2000 X. ✦ ✦

THE finish of wire in many cases is employed as an indication of quality. This is becoming more important every day. It is a problem which requires study of individual customer requirements and, while the general principals of lubrication which provide for a film between the die and the wire still apply, there are numerous instances where the amount of lubrication must be of a particular type or kept to a minimum.

✦ ✦ ✦

THE quality referred to in this paper does not embrace these various features but pertains to the property of strength, combined with ductility, which is symbolical of the word wire.

✦ ✦ ✦

Strain Distribution

IN a paper presented before this society last October[4], the author called attention to the importance of uniform flow as being the prime factor in the production of quality wire. I would like to take this opportunity to further enlarge on this most important feature.

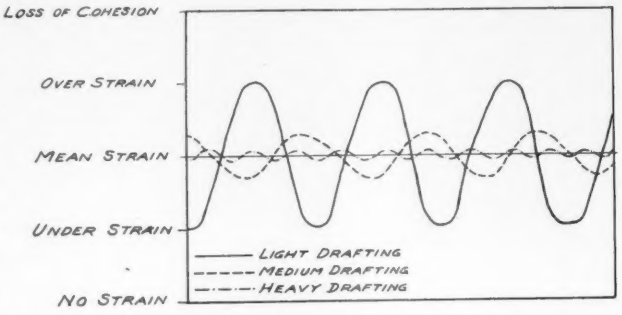
✦ ✦ ✦

WHEN wire is drawn, as shown above, the metal flows by the movement of crystals along planes of easiest slip. In pure metals and solid solution the resistance to slip, while being present in varying degrees, depending on the grain size and the inherent plasticity of the metal, is not confined to certain areas. As a result of this the early stages of cold working will produce uniform strain distribution. When, however, as in the case of aggregates, there exists in the metal areas of varying degrees of hardness the distribution of strain may not be uniform. The degree of uniformity that may exist in a piece of wire depends on —

1st—The amount of drafting
2nd—The degree of variation in hardness present.

✦ ✦ ✦

STEELS containing free ferrite and cementite in the form of globules or spheroids will have a degree of hardness variation which no amount of drafting will overcome. The same is true of structures containing the brittle constituent martensite. Steels containing ferrite and pearlite will show a varying degree of strain distribution, depending on the nature of the pearlite and the particle size of the free ferrite. If the pearlite is of the coarse type the wire produced will be of poor quality and drafting will not effect a uniform distribution of strain. If, however, the structure of fine pearlite is present and the free ferrite is not precipitated in large particles, the steel may lend itself readily to cold working and be ductile over a wide range of reduction. The plasticity of pearlite depends on the thickness of the plates of cementite, for while the cementite itself is little affected, the manner in which this structure lends itself to the distortion associated with deformation is determined by the plate thickness. It is for this reason that a fine pearlitic structure is desired. To effect the maximum strain distribution and thereby the maximum quality, the steel should be either of the solid solution type or consist wholly of fine pearlite. By the use of manganese in the case of the steels with a carbon content below the Eutectoid composition of .85%, the hardness and resistance to plastic deformation of the ferrite is increased. This creates less variation between the ductility of the free ferrite and the various structures of pearlite which may be present and more uniform strain distribution results.



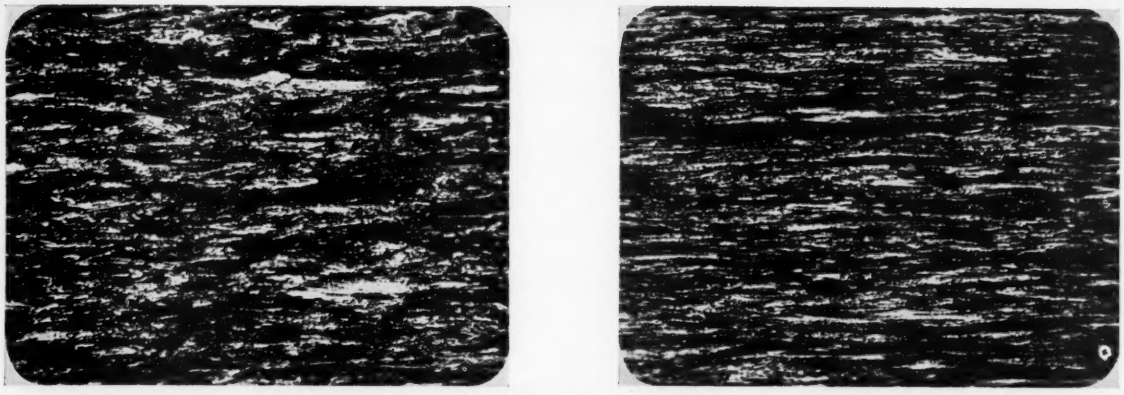
Distrbution of Cold Working Strains.
Fig. 7

BECAUSE of our inability to measure the microscopic distribution of the strains that exist after cold working we are unable to arrive at any definite values for over strain or under strain. However, the diagram shown in Figure 7 may serve to demonstrate this feature. These curves represent the result of an extensive study of cold drawn steel under the microscope, and are intended to show the variations above and below the mean strain. The photomicrographs shown in Figure 8 show the appearance of the microstructure of high carbon steel wire as the strain distribution increases. The change in ductility of the wire resulting from the strain distribution is shown below:

Reduction	**50%**	**85%**
Twists in 100 Dia.	**27**	**33**
Right Angle Bends	**6**	**8**

✦ ✦ ✦

IN the case shown above an increase in cold working improved ductility, this indicates that the non uniformity of the strain distribution has not been carried to the point which resulted in serious over strain. It also indicates that the structure as a whole does not contain areas which seriously resist deformation. The fact that the ductility tests show low ductility in the case of the 50% reduction and higher ductility on the 85% reduction demonstrates that the ductility tests exert a different type of working on the metal than does wire drawing. In the tests, we have a continued straining of the already overstrained areas without equalizing the strain distribution, while in wire drawing the hardness of the strained areas, as it develops, offers resistance to further deformation with the result that the under strained areas gradually become strained to a point in hardness equal to the previous over strained areas, thereby creating a more even strain distribution. When the ductility tests are applied to the evenly strained materials, it is effective



Drawn 50% Drawn 85%

Fig. 8. Showing how Increased Drafting Distributes Cold Working strains in High Carbon Steel Wire — 200 X.

✦ ✦ ✦

over the whole cross sectional areas and higher values result.

✦ ✦ ✦

WHEN because of the hardness of certain areas they offer considerable resistance to deformation, continued working will not improve ductility but may lower it. Areas of coarse pearlite may be little affected by cold working even after considerable reduction. Free cementite and martensite because of their hardness and low plasticity are little affected by cold work. When because of the inability of certain areas to deform the burden of deformation is taken up by a softer area, such as free ferrite, the overstraining may develop to the extent that the atomic cohesion is destroyed and actual internal ruptures occur. In Figure 9 is shown an area of martensite which has caused severe over straining and rupture. In this case the free ferrite and pearlite have carried the burden of the deformation. Cuppy wire of which we are all more or less familiar is the result of severe over strain which has caused internal ruptures. In Figure 10 is shown a sample of cuppy wire sectioned through the center parallel with the axis. Most of the cuppy wire produced is a result of a segregation of carbon at the axis. There has come to the author's attention however a number of instances where large areas of coarse pearlite has caused cuppy wire. The strain distribution diagram shown in Figure 11 demonstrates the variations that may exist when certain areas are strained beyond the limits of atomic cohesion.

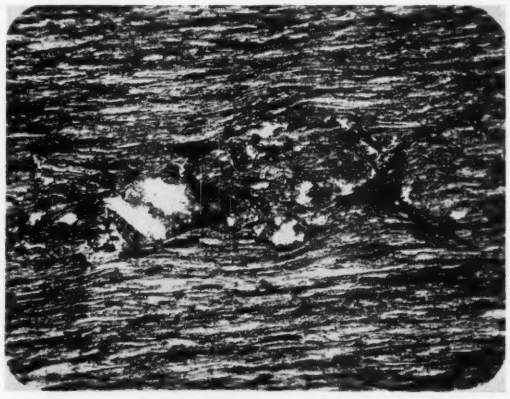


Fig. 9. Atomic Cohesion Destroyed Due to Martensitic (White) Areas in Steel Wire — 200 X. ✦ ✦ ✦ ✦

✦ ✦ ✦

A CLOSE examination of Figure 9 will reveal a feature to which I would like to call your attention. This area of martensite was the only area of its kind in the entire cross section examined and the amount of reduction was not sufficient to justify the fracture. It indicates a condition however which the author has noted on several occasions. While the distribution of cold work is general through the cross section of a sample, this compensating influence has its limitations. That is the rate at which deformation occurs determines the extent to which one area will compensate for another. Particles such as the martensitic area shown in Figure 9 effect such as uneven distribution in a limited area that the speed at which the drawing is done does not permit of compensation with other areas. This same feature is true in much smaller particles than that shown here. It points to the reason for limiting the rate of deformation by the control of the speed of drawing. While it is impossible or at least not practical to consider reducing speeds to the point of permitting strain compensation in a steel such as that shown in Figure 9, any metals containing areas which vary in hardness must be deformated at a rate slow enough to permit flow, or internal fractures will result. If the steel is in ideal condition for drawing, speed with-

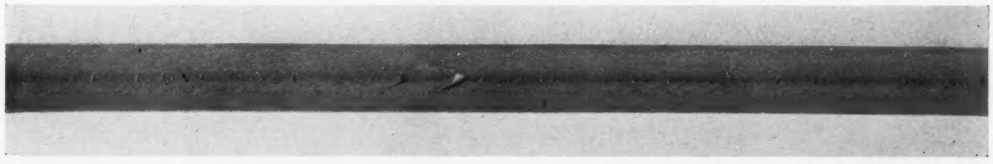


Fig. 10. Cuppy Wire Due to Axial Segregation — 6 X. ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

in reason will not injure it. If, however, a poorly patented high carbon wire is drawn even at a normal or low speed rupture of a similar nature may develop, which would render it inherently brittle.

✦ ✦ ✦

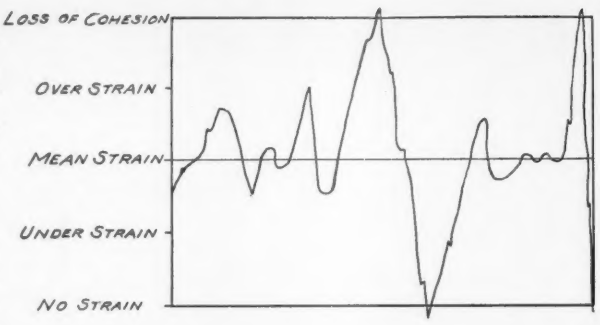
THE amount of reduction per draft has a similar effect on the rate at which the strain is distributed and it is often the case where, by the use of lighter drafts, wire which would otherwise be brittle will be ductile. When the maximum in quality is desired, slow speeds and light drafts, within reason, should be employed. These alone will not be sufficient for it is imperative that due consideration be given to the micro-structure. With the proper micro-structure the need of slower speeds and lighter drafts to produce high quality wire is less. It is in this connection that the application of scientific knowledge can be of assistance in producing a high quality wire economically.

✦ ✦ ✦

AN example of the cold working properties of metals may be had from a study of the cold drawn structure of spheroidized cementite in high carbon steel, a photomicrograph of which is shown in Figure 12. This represents a sample of high carbon steel wire which had been annealed in process followed by 80% reduction, employing 6 drafts.

✦ ✦ ✦

WE have in this sample two constituents only; free ferrite and free cementite. The free ferrite as we know is ductile and flows readily. The free cementite resists plastic deformation. As a result of this, all of the cold work and reduction in area has affected the free ferrite only. The wire was soft, resembling a low carbon wire, yet it was brittle and would break on a small amount of bending. In this instance, the same condition existed as shown in Figure 9 but because of the minute particle size it was difficult to see. The wire was inherently brittle and subsequent heat treatment did not correct it.



Strain Distribution associated with Cold Working of Metals containing Hard Particles which do not Deform.

FIG. 11

✦ ✦ ✦

IT is the author's belief that all of the brittleness or lack of ductility associated with wire results either from a non uniform strain distribution of the type shown in Figure 8 or the actual internal fractures shown in Figure 9.

✦ ✦ ✦

IN an article published in the August 1935 issue of Metal Progress[5] the author called attention to the inability of structures containing fine particles of iron carbide to lend themselves to plastic deformation. This same principle applies to any steels in which there is present a large amount of free cementite in the spheroidal condition. Brittle wire resulting from slack patenting is produced in the same manner. Due to too low a temperature or too short a time at temperature, or both, the solution of the constituents and recrystallization is not complete and the iron carbide is present in the form of fine particles. Steels which because of faulty steel making practices do not respond properly to the patenting treatment will lower the wire quality in the same manner.

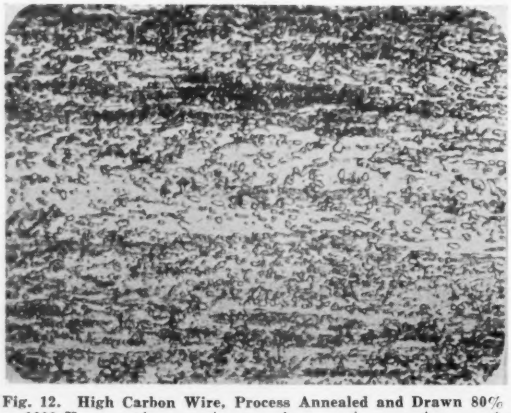


Fig. 12. High Carbon Wire, Process Annealed and Drawn 80% — 1000 X.

✦ ✦ ✦

Conditioning Treatments

ONE of the most important steps in the development of the manufacture of wire was the introduction of the patenting treatment. While undoubtedly the method employed originally was crude, as compared with our present process, it marked the beginning of the use of a conditioning treatment for wire drawing. Today in the manufacture of steel wire the patenting treatment, employing both the lead and air quench, is extensively used and the remarkable physical properties of the material being produced is a credit to the wire industry.

✦ ✦ ✦

OTHER cold working processes such as the deep drawing of sheets and the cold heading of wire to form bolts are employing a conditioning treatment and the time is not far removed when more attention will be given to the condition of low carbon steel for wire drawing purposes. The requirements of uniformity for wire to be formed in automatic machines is becoming more severe and the variation resulting from grain size and rate of cool of the hot rolled rods will need to be controlled to increase uniformity. The continuous anneal is now being employed to some extent to overcome the non-uniformity associated with the pot anneal; a requirement that was almost non-existant a few years ago.

✦ ✦ ✦

THE size of the grain in sheets for deep drawing purposes has become of considerable importance both in the promotion of ductility and the control of finish. Too fine

a grain will lower ductility and too coarse a grain, while promoting ductility, will leave a roughened surface. Both these problems are in line with the slip interference theory. The resistance to slip afforded by an increased number of grains in the fine grain material reduces ductility, while in the coarse grain material the length of the block movement of cubes along crystallographic planes may be enough to make them visible on the smooth surface of the stock.

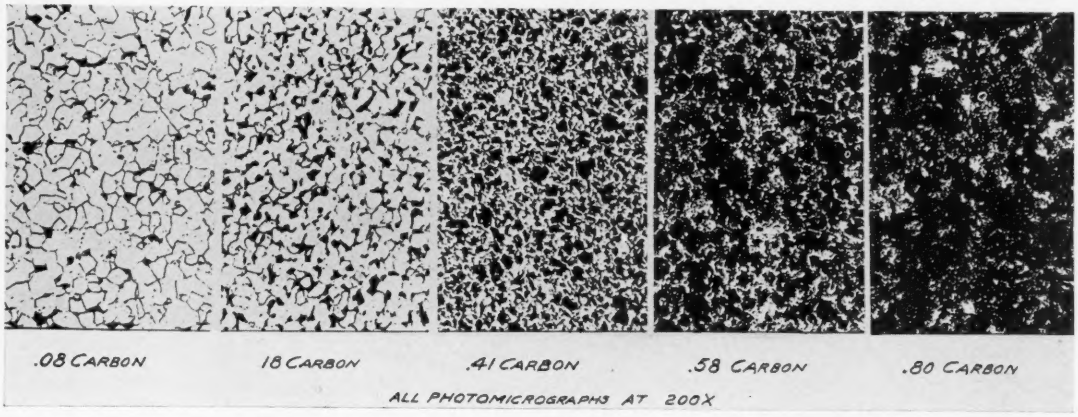


Fig. 13. Influence of Carbon Content on the Amount of Free Ferrite and Pearlite Formed. Taken on No. 5 Rods in the as Rolled Condition.

✦ ✦ ✦

IN the cold heading industry a normalizing treatment is being employed. By this treatment the size of the grain is increased and the steel rendered more ductile. This permits of easier flow and reduces the tendency towards the development of cracks in the bolt head.

✦ ✦ ✦

Steel For Wire Drawing

THE general run of steels for wire drawing purposes are divided into two groups:—

Those wherein we depend on the ductility of free ferrite for deformation, such as low carbon materials;—
and
Those wherein we depend on the ductility of the aggregate for deformation such as high carbon steels.

✦ ✦ ✦

IN Figure 13 is shown a series of photomicrographs which demonstrate the influence of carbon on the amount of free ferrite and pearlite present. In the lower carbon range the amount of free ferrite present is sufficient to effect considerable deformation without too great an over strain. The material from .50 carbon up can by a carefully controlled patenting treatment be put into a condition of uniformity of hardness which will produce good wire. The intermediate range from .15% to .5% carbon is seldom employed except for special application. In this range the limited amount of free ferrite lowers the amount of deformation that can be effected in line with Group 1 and the inability of the steel to respond to the patenting treatment prevents the uniform distribution of strain associated with Group 2.

✦ ✦ ✦

THE plasticity of low carbon steel can be considerably increased by the use of the process anneal. By this treatment, which is carried on a temperature of 1300° F or slightly lower, the areas of pearlite are broken down into their component parts, ferrite and cementite, and the actual amount of area resisting deformation is reduced.

✦ ✦ ✦

IN Figure 14 and Figure 15 is shown a sample of low carbon steel before and after the process anneal.

✦ ✦ ✦

BY the use of the patenting treatment in the case of high carbon steels the thickness of the plates of cementite are reduced, thus permitting easier flow of the pearlite and at the same time, the precipitation of free ferrite is retarded (in the case of steels under .85 carbon.) Instead of it being present in the form of large particles or network it is distributed throughout the pearlite. In Figure 16 and 17 is shown a sample of .65 carbon steel in the annealed and patented condition. Note the free ferrite (White) in the annealed structure. The same amount of free ferrite is present in the patented structure but it is distributed so uniformily throughout the pearlite as to make it almost invisible.

✦ ✦ ✦

IN the same manner the free cementite of steels over .85 carbon can be controlled by the patenting treatment.

✦ ✦ ✦

Principles of Patenting

THE control of the type of microstructure resulting from the patenting treatment is based on the complete solution of the constituents and the rate of quench. Both the air and lead patenting process can be used successfully on the steel containing free ferrite. However, it is advisable to employ the lead patenting treatment when steels over .85 carbon are being patented. In using the Figure of .85 as the dividing line between steels containing free ferrite and those containing free cementite, it should be remembered that this is an arbitrary figure. The amount of manganese, chromium, etc., present may be contaminating the cementite and lower this figure by increasing the amount of cementite present for a given carbon content.

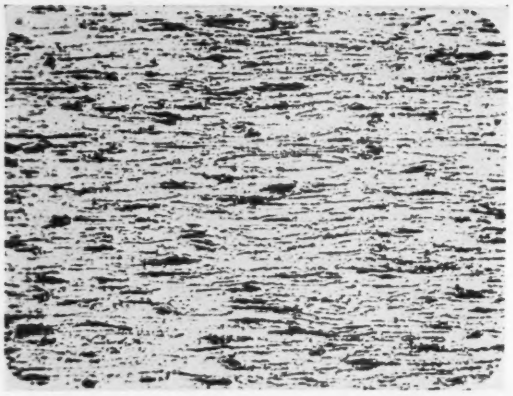


Fig. 14. Low Carbon Steel Wire Drawn 80% — 200 X. ✦

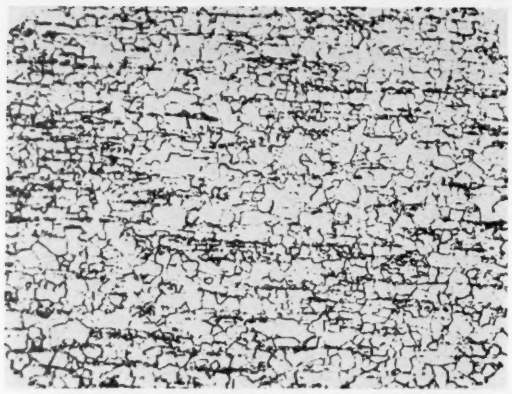


Fig. 15. Same as Figure 14 After the Process Anneal — 200 X.

THE prime purpose of the patenting treatment is to develop a structure as nearly uniform as regards the hardness of different areas as possible. To do this the temperature at which the transformation occurs must be controlled, for as shown by Bain[6] and discussed by the author elsewhere[4], the temperature at which the transformation from Gamma to Alpha iron takes place determines the microstructure developed in steel. This transformation temperature designated as the Ar 1 transformation is influenced by the analysis, the size of the austenitic grains, the temperature from which the cooling begins and the quenching medium. As the carbon content of steel is lowered it becomes increasingly difficult to effect a sufficient lowering of the Ar 1 to produce the structure of fine pearlite and to control the precipitation of ferrite. Because of this same influence of analysis there is less danger of developing the structure of martensite in lower carbon steels than in high carbon steels. The air patenting while satisfactory for steels under .85% carbon does not permit of sufficient control of the temperature at which transformation occurs to develop an extremely fine pearlite and at the same time to be certain of the absence of martensite when steels above .85% carbon are being treated. By the use of the lead bath as quenching medium the Ar 1 can be better controlled and structure of fine pearlite developed without the presence of martensite.

✦ ✦ ✦

A KNOWLEDGE of the grain coarsening temperature of the steel being patented is important in controlling the austenitic grain size. The McQuaid Ehn Grain Size test may be employed as a means of classifying the steels being used. By the use of a coarse grain steel as determined by the McQuaid Ehn Grain Size Test the grain coarsening temperature will be lowered.

✦ ✦ ✦

THE amount of drafting applied to a wire prior to patenting may also influence the grain coarsening temperature. References to this subject were made in the paper presented before you last year[4]. Recent work has shown that a small amount of reduction does cause an erratic grain coarsening but that heavier drafting raises the grain coarsening temperature. This is due to the variation in grain growth which results from a variation in strain distribution. These references to grain coarsening temperatures apply principally to fine or medium fine grain steels as determined by the McQuaid Ehn Grain Size Test. The grain coarsening temperature of all the coarse grain steels being low as compared with the patenting temperature.

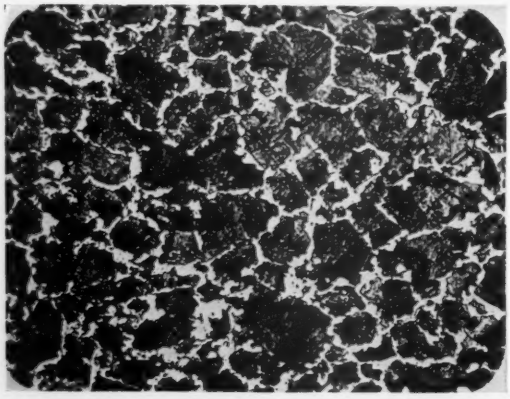


Fig. 16. Annealed .65 Carbon Steel — 200 X. ✦ ✦

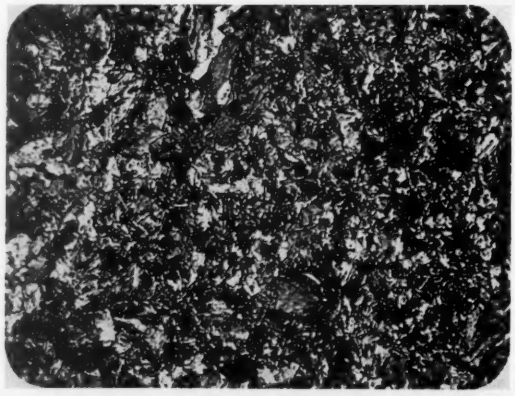


Fig. 17. Same as Figure 16 After Air Patenting. Note the Absence of Ferrite Net Work — 200 X. ✦ ✦ ✦

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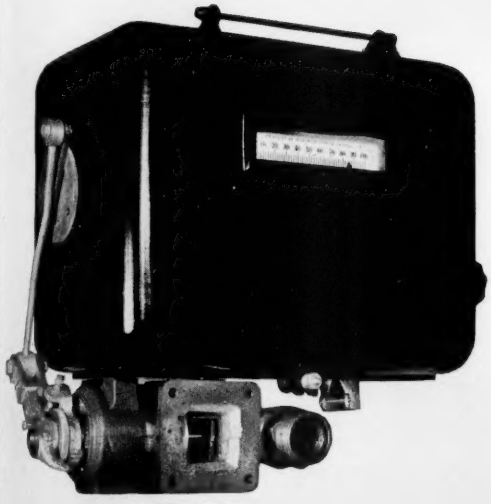

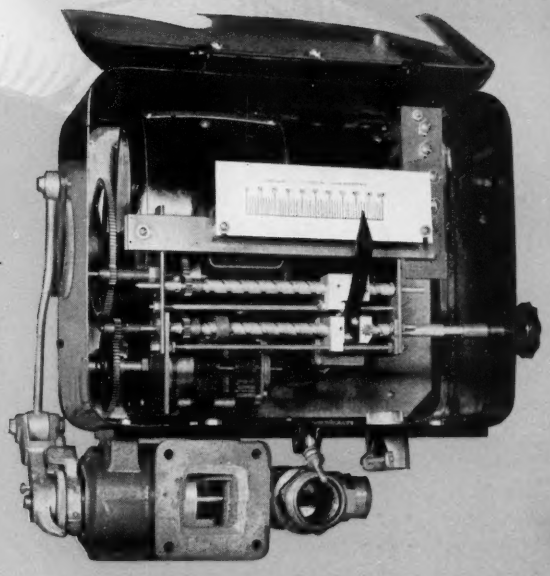

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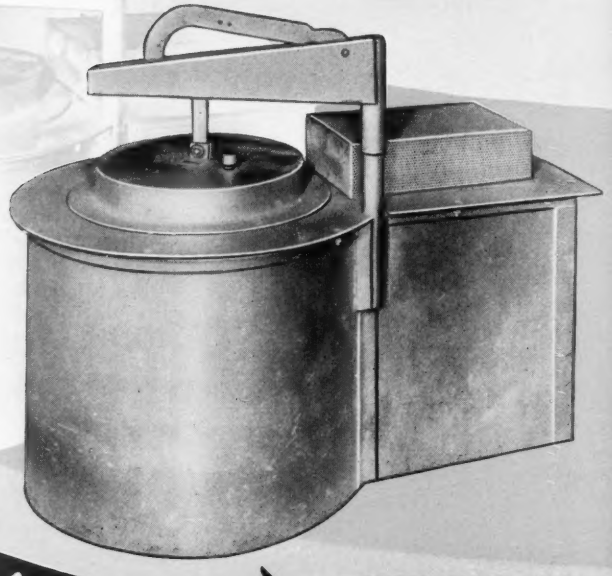

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The Austenitic Treatment

IN preparing alloy steels for cold working, the wire drawer is confronted with low plasticity because of the effect of alloys. While, due to the difficulties encountered in drafting and the questionable improvement in quality resulting from their use as compared with the straight carbon steels, there is only a limited tonnage of alloy steel wire produced, the use of stainless steel wire has become an important commodity. The majority of the stainless steel wire being produced is made from chromium-nickel steels which can be made austenitic by heat treatment. The steel is first heated to a temperature of about 1850°F followed by a water quench. This produces an austenitic structure such as is shown in Figure 4 and the metal as prepared for wire drawing is of the type one (above), that is; it is in the solid solution form.

✦ ✦ ✦

SUMMARY

THE Slip Interference Theory of Jefferies and Archer, in the author's opinion offers the most adequate explanation of the hardening of metals as a result of cold working.

✦ ✦ ✦

WIRE is drawn from two types of metals—

First: Pure Metals and Solid Solutions.

Second: Aggregates.

CHROMIUM — Nickel steels, Copper Zinc Alloys and the ferrite of commercial steels are examples of solid solutions. The manganese, phosphorus and silicon in steel form a solid solution with the iron and influence the plasticity of the ferrite.

✦ ✦ ✦

STEEL containing iron carbide in the form of free cementite or combined with ferrite to form pearlite and copper containing copper oxide are examples of aggregates.

✦ ✦ ✦

THE term quality may have a broad meaning when used in connection with wire. It is used here, however, to indicate strength combined with ductility.

✦ ✦ ✦

THE amount of drafting and the degree of variation in hardness of different areas are the prime factors which influence strain distribution.

✦ ✦ ✦

AREAS which are strained beyond the limit of atomic cohesion will produce internal fractures and the wire rendered inherently brittle.

✦ ✦ ✦

THE rate at which deformation is carried on, has a decided influence on the quality of the wire. The more uniform the metal is, as regards variation in hardness, the faster the deformation can be made.

CUPPY wire is the result of internal fractures and is usually traceable to a segregation of elements at the axis of the wire.

✦ ✦ ✦

WHILE most of the references contained here-in pertain to ferrous wire drawing, the same principles apply to drawing of non-ferrous metals and alloys.

✦ ✦ ✦

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Trans. Amer. Ins. of Mining and Metallurgical Engineers—Vol. 100—1932. By E. C. Bain.

ONCE again the author wishes to express his appreciation to the Management of the Wickwire Spencer Steel Company, whose broad minded views and keen appreciation of the value of scientific knowledge has made the presentation of this paper possible.

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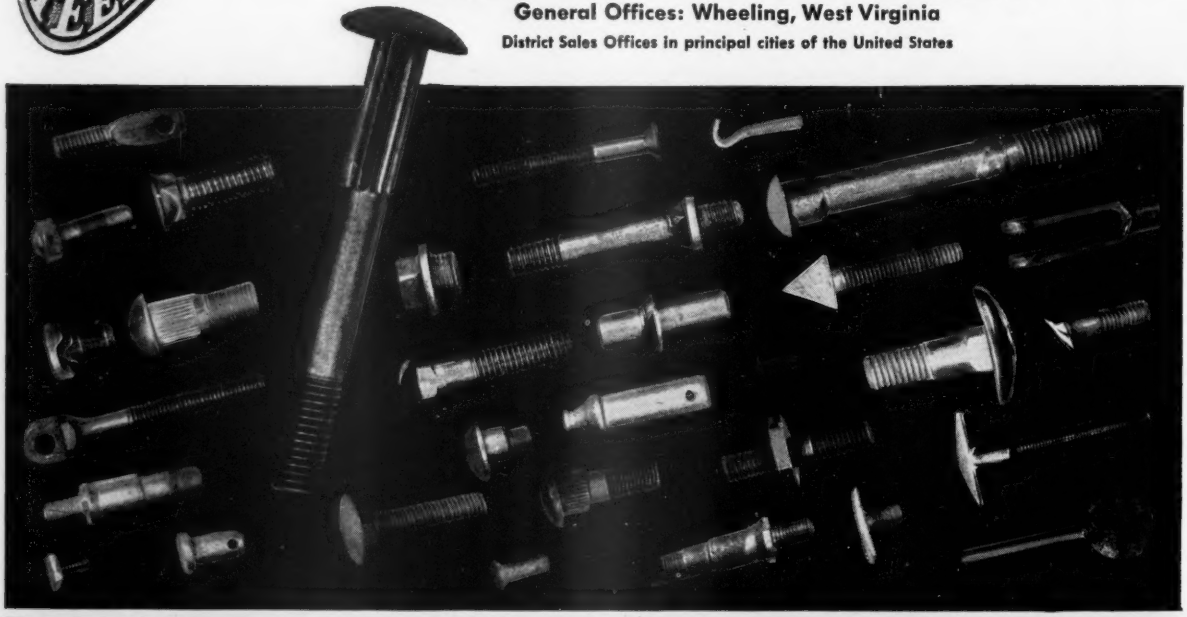


IT'S WHEELING STEEL

Power For Cascade Drawing of Copper

By Paul M. Mueller, Mechanical Engineer,
Revere Copper & Brass, Inc.., New York, N. Y.

In answer to criticism that the published data on the drawing of wire is entirely theoretical or at least so involved that its practical application is lost, the author presents data covering the ranges of breakdown and intermediate drawing from which it is simple to calculate a given series of drafts for the various types of drawing equipment in general use. ✦ ✦ ✦

THE criticism has been made occasionally that the published data on the drawing of wire is entirely theoretical or at least so involved, that its practical application is lost to many who might use it to advantage.

✦ ✦ ✦

TO answer this criticism in part, the writer can offer data covering the ranges of break-down and intermediate drawing, arranged in chart form, from which it is quite simple to calculate a given series of drafts applying to the types of drawing equipment in general use.

✦ ✦ ✦

WHILE this data has a theoretical background, the constants of the formula have been developed by empirical tests extending over several years actual operation in the shop under normal operating conditions. Hence, it is believed, it represents a good average of the usual conditions encountered with respect to both the condition of the material drawn and the condition of the dies and lubricant.

✦ ✦ ✦

EARLY in 1930, Lee Vaughn furnished us with the formula which his company considered applicable to the breakdown range. This formula determines the die seat pressure or the pull on the wire necessary to effect the reduction.

$$P = F \times (A_1 - A_2) \times \frac{(T_1 - T_2)}{2}$$

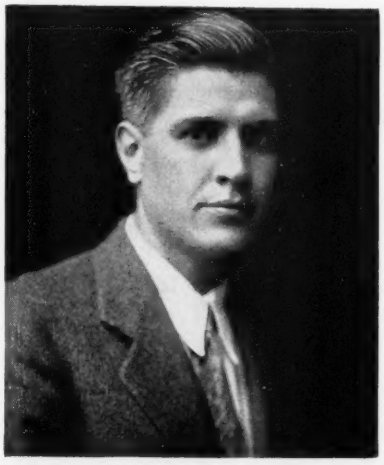
P=die seat pressure
A_1=Cross-sectional area of entering wire
A_2=Cross-sectional area of leaving wire
T_1=Tensile strength of entering wire
T_2=Tensile strength of leaving wire
F=Constant

✦ ✦ ✦

THIS equation states that the die pull is proportional to the area reduced and the average tensile strength, modified by an experience factor F which covers die friction and the ratio between "resistance to compression" and the more easily determined "tensile strength".

✦ ✦ ✦

HAVING available about 2000 records of test pulls, we set about determining an average value of the constant F. A graph was made between F, area reduced, and temper, and many points plotted. These points fell fortuitously because of the large number of conditions encountered, but on the average grouped themselves along a curve whose value for F varied between 1.1, where the wire was of large diameter and soft, and 4.0 where the wire was fine and hard.



PAUL M. MUELLER

Studied Mechanical Engineering Iowa State College. Spent several years Johns Hopkins University under Dr. R. W. Wood on problems connected with physical optics. Prior to 1929 Metrologist for Pratt & Whitney Co., principally occupied with the development of standards of length, precise methods of manufacture, and national standardization with such organizations as American Petroleum Inst., etc. 1929 became Chief of Mechanical Engineering staff of General Cable Corp. During this connection was employed in the improvement of equipment for wire drawing, stranding, extruding of lead, and the standardization of reels and spools, and was responsible for the equipment for the manufacture of hollow core cable at their Los Angeles plant. 1935 Engineer, Revere Brass & Copper, Inc. Member, Wire Association. Member, A. S. M. E.

✦ ✦ ✦

A NUMBER of cases which varied widely from the average were investigated. In each case the variation could be attributed to some peculiarity in the die, such as excessively long land, angle wider than the usual 16°, or trumpet shape instead of truly conical. The diamond dies which were all trumpet shaped were particularly variable and unpredictable.

✦ ✦ ✦

HAVING determined a tentative value of the constant the formula was plotted in the more convenient form shown in Fig. II and check tests were begun in the shop on production runs.

✦ ✦ ✦

IT was soon apparent that the values developed from single dies were too high when applied to a series of drafts in cascade, and the curves were modified to agree. After two years of comparison of the test readings versus chart calculation covering the breakdown and intermediate drawing in five operating plants, the chart data was found to be able to predict within an error of 5%.

✦ ✦ ✦

TO illustrate how the data is to be used, a sample tabulation of the calculations of an actual test on a rod machine are shown in Table I. The first column shows the

starting size or rod diameter and the sequence of the 9 dies in the total draft. In column No. 2 the corresponding areas of cross-section of the wire are next calculated and set down. The third column gives the percent reduction for each draft.

✦ ✦ ✦

THE actual wire pull or die seat pressure (col. 7) is obtained by multiplying the wire pull factor by the leaving area of the wire (col. 6 x col. 2).

✦ ✦ ✦

FROM here on the calculation for horsepower follows the usual method. The wire pull multiplied by the surface velocity of the pulling capstan (col. 8) results in the ft. pounds per minute expended at each drawing station. These divided by 33,000 give col. 9 in horsepower.

✦ ✦ ✦

IT is necessary to use the surface velocity of the capstan instead of the speed of the wire, because the wire is usually running slower than the capstan and is not a true index of the power used.

✦ ✦ ✦

THE chart in Fig. II can not be used to determine the die pull factor for single drafts. This factor has been determined for the usual practice in cascade drawing and as noted previously is somewhat lower than the factor for single drawing. An increase of at least 10% should be made to the chart values to arrive at a safe value.

✦ ✦ ✦

THE reason for the lower value in cascade probably may be assigned to the small amount of backpull on the wire entering each die. This backpull is the tension required to make the wire snub the capstans. With two wraps per capstan, this tension is appreciable and could easily account for the increased die efficiency in cascade.

✦ ✦ ✦

NO rational explanation has been found for the concavity of the curve family of Fig. II. When the die pull factor for a single die (not in cascade) is plotted in the same manner, it invariably is a straight line. When plotted together

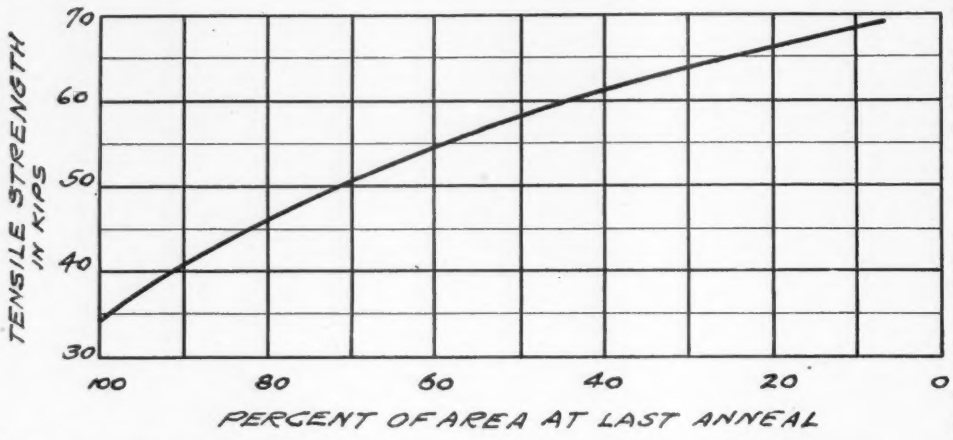


Fig. I. Rate of Cold Work Hardening for Copper.

✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

IN the fourth column the area of the leaving wire is expressed in percent of the original rod size. These values are used in connection with the curve showing rate of work hardening Fig. I to determine the values in column 5. Column 5 is an expression of the temper or hardness of the wire as it enters any given die. (If the sequence does not begin with a soft rod. the "original area" is the area of the wire at its last anneal and the temper is determined from this as a basis.)

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THE wire pull factor (col. No. 6) is now taken from the chart (Fig. II) using the figures in column 3 as abscissae, finding the ordinate in the family of curves with a corresponding temper.

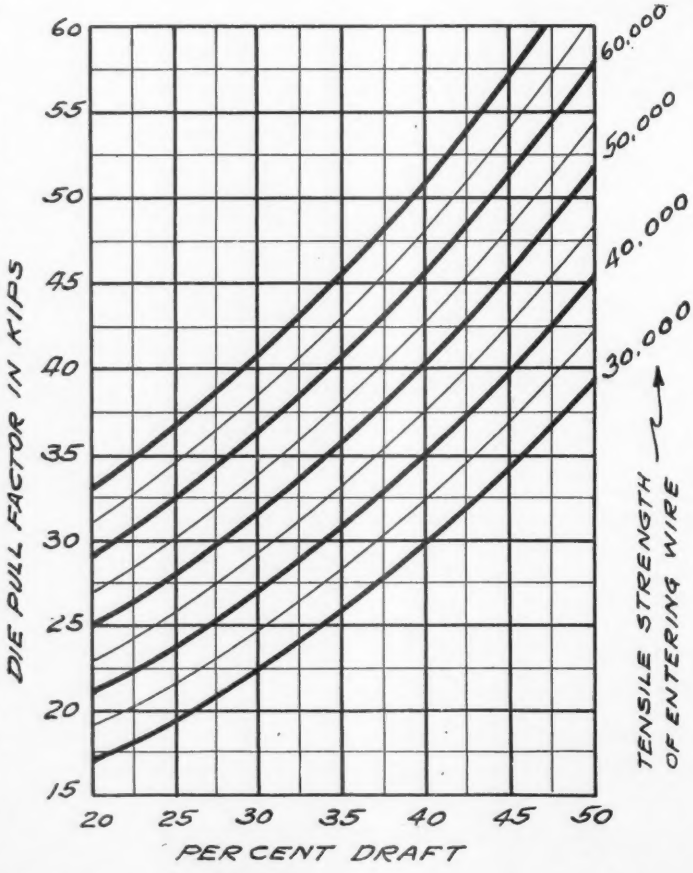

Fig. II. Chart for Determining Die Pull.

✦ ✦ ✦ ✦ ✦

TABLE I

TEST OF ROD MACHINE DRAWING FROM 5/16 TO .072
IN 9 DIES AT 2000 F. P. M.

(1) Diameter Of Wire	(2) Area Sq. In.	(3) % Red.	(4) % Orig.	(5) Tensile Entering	(6) Die Pull Factor	(7) Wire Pull Pounds	(8) Drum Velocity	(9) H.P.
.323	.08194		100					
.230	.04155	49.3	50.7	34000	41000	1705	360	18.60
.1855	.02702	34.9	32.9	57000	39000	1055	453	14.50
.152	.01815	32.8	22.3	63000	40000	726	569	12.50
.128	.01297	28.7	15.9	65000	37000	480	719	10.40
.114	.01028	20.6	12.6	67000	31700	326	903	8.90
.102	.00816	20.6	10.0	68000	32000	261	1139	9.00
.091	.00647	20.6	7.9	68200	32000	207	1435	9.00
.081	.00513	20.6	6.3	68500	32250	165	1807	9.05
.072	.00407	20.6		69000	32500	132	2000	8.00
					Total HP at the capstans			99.95
					Add 15% for motor and drive			15.00
					Total calculated HP input			115.00
					Actual test motor input			116.70

TABLE II

SUMMARY OF MISCELLANEOUS COMPARATIVE TESTS

No. of Runs Averaged	Cascade Sequence		CAPSTAN HORSEPOWER Calc.	Actual
6	¼ Rod — .072	8 Dies	80.31	82.4
7	¼ Rod — .081	7 Dies	89.46	90.8
8	5/16 Rod — .072	9 Dies	100.00	105.9
6	5/16 Rod — .072	8 Dies	113.2	117.6
2	5/16 Rod — .081	7 Dies	131.4	124.7

Note—These test runs were made on existing machines not designed to have minimum slip at the sequences chosen.

the cascade curve is about 5% lower than the straight line for single draft at 20% and 50% reduction and 15% lower at a reduction of 35%.

✦ ✦ ✦

TO explain this on the basis of increased backpull midway in the sequence, the assumption would have to be made that the snubbing action of the wire on the capstans was somehow reduced. Of course, at this position the wire is quite springy and has a rather large diameter ratio to the diameter of the capstan, and consequently requires more tension to snub.

✦ ✦ ✦

BUT this is merely conjecture with which to start arguments. Whatever the reason, the position and shape of the curves have been established practically and they seem to work.

ASIDE from checking the detail specifications of proposed equipment, the above data has been useful in local redesign and rebuilding of old equipment when adapting it to new operating conditions. A power analysis of a machine often times may bring to light hidden inefficiencies in the driving mechanism of the machine or indicate a poor condition in dies or lubrication, and point the way to correction.

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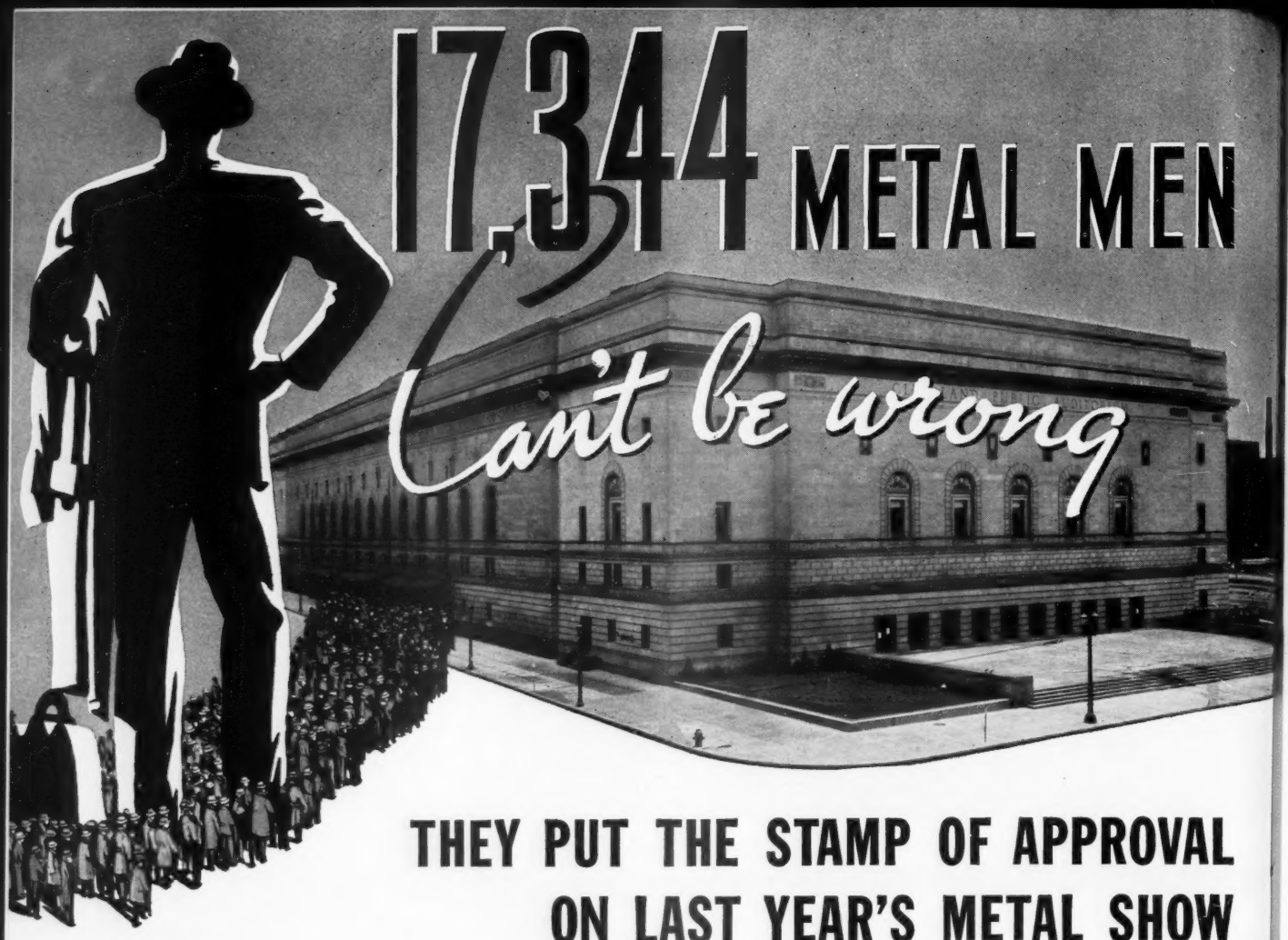

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COOPERATING SOCIETIES

Atmospheres and Furnaces In The Wire Industry

By H. M. Heyn, Engineer,

In Charge of Heat Treating Division,
Surface Combustion Corporation, Toledo, Ohio.

A PAPER dealing with atmospheres and furnaces in the wire industry. A recognition on the part of the wire producers of better metallurgical control and the many ramifications for exercising this control becomes apparent considering the many different analyses of steel required by the users of wire. This has necessarily called for better heat treatment.

The many advantages of the application of prepared gas atmospheres to process furnaces are apparent although each application must necessarily be decided after careful consideration is given to all of the factors entering into an intelligent determination of costs.

✦ ✦ ✦

Controlled atmospheres necessarily do not apply to prepared atmospheres. Automatic proportioning gas burning equipment, the carbon diffuser or atmosphere conditioner suffice for many applications. The necessity of better understanding the chemistry of prepared gas atmospheres, and the mechanics of application, become apparent when thought and study is given to the many variations that will result due to catalytic effect and other unbalancing conditions.

THE many demands for better quality wire has resulted in necessary improvements not only in furnaces required for wire treatment, machinery in wire manufacturing, but also in metallurgical control of steel making, in melting practice and the many other phases that enter into wire manufacture.

✦ ✦ ✦

ONLY a few years ago when wire was principally used for nails, barb wire and fence wire, a relatively few metallurgical and physical specifications met the demands. Today, with new markets being found, with ever-increasing exacting demands, the producers are confronted with developing ways and means of meeting these demands through better metallurgical control and better manufacturing and furnace equipment.

✦ ✦ ✦

THE automotive industry has exerted a very noticeable influence on the wire industry just as it has in many other industries. The rigidness of specifications on bolt stock, screw and nut stock, and rod, that is used for the manufacturing of many products; the necessity of uniformity of analysis from coil to coil in both high and low carbon steel, requires exacting control from the convertor—open hearth or electric melting furnace—to the finished product, that a few years ago would have been regarded as unnecessary if not ridiculous. The improvements that have been made are a credit to the understanding and cooperation between the management, the engineer, and the metallurgist.

✦ ✦ ✦

H. M. HEYN

Educated in the East, majoring in thermodynamics and works engineering, at the Cooper Union and Pratt Institutes. After a short connection with the chemical industry, he joined the Surface Combustion organization, eighteen years ago. During this time he has had an opportunity of being a factor in furnace development from the introduction of the first scientific furnace employing automatic proportioning burning of gas to the present-day furnace utilizing controlled atmospheres. Member Wire Association.

THE many ramifications entering into the control of wire stock, the chemical analysis, surface conditioning, when 72 different specifications of billets are necessarily carried in stock to meet the demands of users, is ably covered by **J. H. Shilling** of the Youngstown Sheet and Tube Company in the June issue of Wire and Wire Products.

✦ ✦ ✦

THE "Recent Developments in Steel Wire Technology" by **S. A. Bralev** in the July issue of Wire and Wire Products covers a study of the fundamental questions for which satisfactory information must be obtained in order to produce types of specified wire. This paper emphasizes the necessity for correct rod rolling to meet required wire properties.

✦ ✦ ✦

FURNACES and furnace atmospheres have played an important part in the progress made in the wire industry. The story of the part played by furnaces and furnace atmospheres is exceedingly interesting and to this story the major portion of this paper will be devoted.

✦ ✦ ✦

Value of Normalizing

BEFORE considering the many different kinds of furnaces and furnace atmospheres it might be well to briefly touch on some of the physical changes that take

place in metals. In this connection it is of interest to draw on analogy between metals in general and life in the biological sense. While the similarity might not be very apparent, nevertheless a very striking similarity does exist and in many aspects the heat treater and metallurgist is comparable to the family doctor.

✦ ✦ ✦

BIOLOGISTS tell us that there are two things that determine the value of life — heredity and environment. Both are applicable to things as well as to persons. Depending on conditions, at times heredity is of greatest importance; at other times, environment, but when both are analyzed the entire history of a person or a thing is revealed.

✦ ✦ ✦

HEREDITY plays a very important part in the heat treatment of metals. It is only natural that each operation the metal has passed through from the crude ore to the saleable product has made physical changes in it, making it as distinctly individual as any person.

✦ ✦ ✦

IF the heat treater undertakes to apply the principles of his art without taking into account the individuality of his material, his results are apt to be disappointing. For this reason the first step in the heat treatment of any steel is that of normalizing, whereby these effects of heredity may be wiped out. Normalizing has been described by Tiemann as,—

"a form of annealing known as normalizing consists in reheating to a temperature above the critical range, holding at that temperature a certain length of time and then cooling in air. It is commercially used to secure uniform conditions on materials treated in various ways, or where, as in the case of billets, the finishing temperature and amount of hot working have resulted in a very coarse grain."

✦ ✦ ✦

THE art of normalizing is fundamental in heat treating. It shows the distinct advantage that the steel treater has over the family doctor, for the former is thus able to eliminate all the ills of his subject by a suitable heat treatment. In addition to this he can impart whatever characteristics he may desire that are within the range of possibility of his material. He cannot make a tool steel from low carbon metal, nor can he make a heat resisting alloy from tool steel, but he can develop the full scale of possibility of each individual analysis.

Rules of Heat Treating

IN order to do this he must follow the rules, and these are just as exacting as in any well regulated society. Steels are almost human in the way they respond to correct treatment. Give them the right temperature in the correct atmosphere for the correct length of time and if they have been normalized, they will always act in the same way. Steel will respond enthusiastically to facts, but it has no regard for theory. We learn the rules of heat treating not by philosophizing but by experimenting.

✦ ✦ ✦

A VAST accumulation of experience has succeeded in reducing these many rules to a code that is compact and easy to understand.

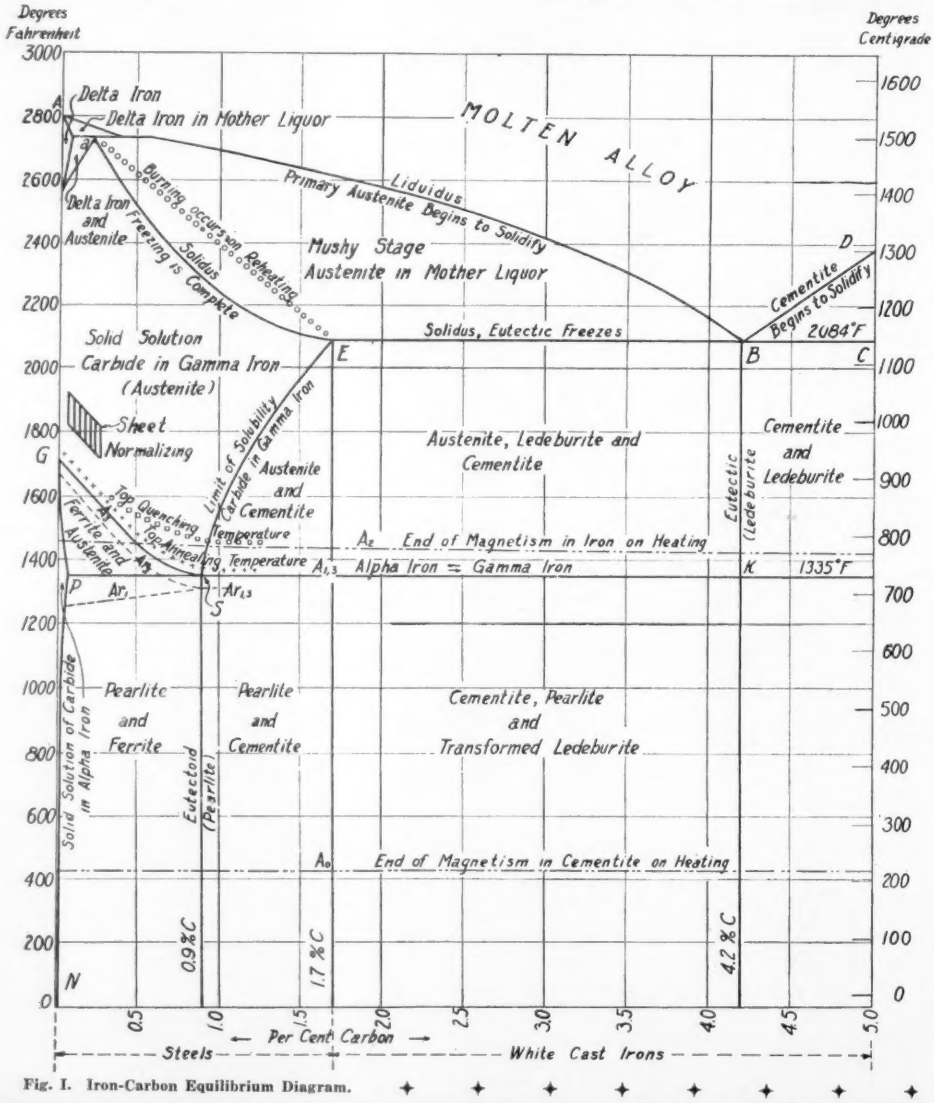


Fig. I. Iron-Carbon Equilibrium Diagram.

✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

This code has been plotted as a chart and as such is known as The Iron Carbon Equilibrium Diagram. See Figure I. It is the chart which enables those interested in the treatment of steel to deal effectively with the heredity of a piece of steel and to impart those internal characteristics that determine the physical properties. You will find the lines on this chart are a series of points showing the temperature and carbon content at which important changes take place. The heat treater will take steel, whose carbon content is known, and will raise its temperature to a point indicated on the chart with full assurance that it will be transformed in strict accord with the rules, if he has done his work right. The iron carbon equilibrium diagram is very well known so that it is not necessary to give a detailed explanation. The diagram is almost self-explanatory in that the different changes which take place at different points on the diagram are outlined very completely in the diagram.

✦ ✦ ✦

The Carbon Oxygen Iron Diagram

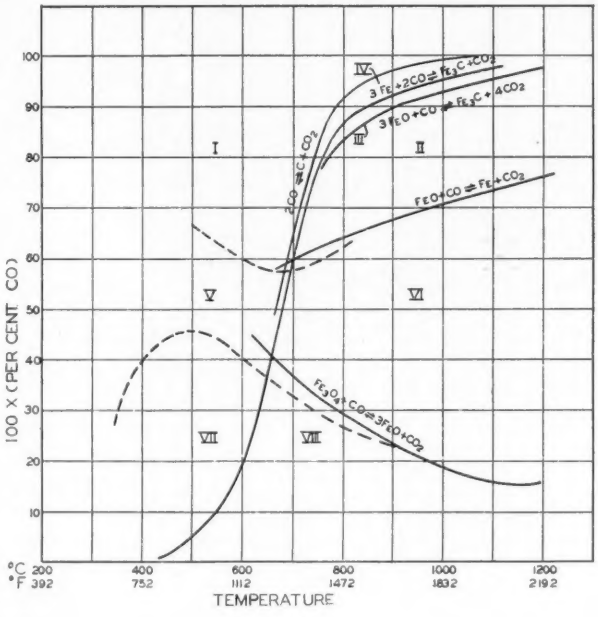
IN addition to the influences of heredity in the making and treatment of steel, we find that environment also is of great importance. If a piece of iron be placed in a dry and arid atmosphere, it will remain for years without apparent deterioration. If it be placed in the atmosphere of a mill town or seashore, it will rust badly in a few months. This is essentially a matter of environment rather than heredity, the rate of reaction being set by the character of atmosphere surrounding the metal.

✦ ✦ ✦

FURTHERMORE, the effect of temperature upon these reactions must not be overlooked. As a rule the higher the temperature the more rapid the reaction rates. A piece of steel at atmospheric temperature will oxidize slowly compared with the rate when heated. This difference is noted in the terms used to describe it. We say that steel will rust in the weather but scale under heat. It is oxidation in either case, but the rate is different. Temperature has a most important effect.

✦ ✦ ✦

SCALING of steel may be caused by gases other than oxygen. Carbon Monoxide and Carbon Dioxide have a very great effect upon scaling. They are either friends or enemies. The effect and results of CO and CO_2 as atmospheres have been of interest to manufacturers for years. Numerous investigations have been made and in this case also it has been possible to plot the results in a diagram. This diagram with an accompanying chart is shown in Figure II. They represent the results of hundreds of tests by many investigators. The work is not as well known as the iron carbon equilibrium diagram, although



AUTHORITIES:-

$2\,CO \rightleftharpoons C + CO_2$ — BOUDOUARD

$FeO + CO \rightleftharpoons Fe + CO_2$
$Fe_3O_4 + CO \rightleftharpoons 3FeO + CO_2$
$3FeO + 5CO \rightleftharpoons Fe_3C + 4CO_2$
$3Fe + 2CO \rightleftharpoons Fe_3C + CO_2$ — MATSUBARA

THE DOTTED LINES ARE THOSE OF BAUR AND GLAESSNER

REACTIONS		$2CO \rightleftharpoons C + CO_2$	$FeO + CO \rightleftharpoons Fe + CO_2$	$Fe_3O_4 + CO \rightleftharpoons 3FeO + CO_2$	$3FeO + 5CO \rightleftharpoons Fe_3C + 4CO_2$	$3Fe + 2CO \rightleftharpoons Fe_3C + CO_2$	SOLID END PRODUCTS IN EQUILIBRIUM
THE ARROWS INDICATE THE DIRECTION IN WHICH THE REACTIONS OCCUR IN THE FIELDS I, II, ETC.	I	→	→	→	→	→	Fe_3C AND SOLID C
	II	←	→	→	←	←	METALLIC Fe WITHOUT SOLID C
	III	←	→	→	→	←	METALLIC Fe WITHOUT SOLID C
	IV	←	→	→	→	→	Fe_3C WITHOUT SOLID C
	V	→	←	→	DATA INCONCLUSIVE	DATA INCONCLUSIVE	FeO AND SOLID C
	VI	←	←	→	←	←	FeO WITHOUT SOLID C
	VII	→	←	←	DATA INCONCLUSIVE	DATA INCONCLUSIVE	Fe_3O_4 AND SOLID C
	VIII	←	←	←	DATA INCONCLUSIVE	DATA INCONCLUSIVE	Fe_3O_4 WITHOUT SOLID C

TEMPERATURE – CONCENTRATION DIAGRAM OF IRON-CARBON EQUILIBRIA AT A CONSTANT PRESSURE OF 1 ATMOSPHERE ABS.

Fig. II. Iron-Carbon-Oxygen Equilibrium Diagram. ✦ ✦ ✦ ✦ ✦ ✦ ✦

it covers in a similar manner another phase of heat treating, namely that having to do with the surrounding atmospheres and their effects upon metal surfaces. The heat treating art is not intelligently conducted until a proper understanding is obtained by the use of not only the iron carbon equilibrium diagram but a thorough investigation of the effect of atmospheres.

✦ ✦ ✦

THE results from the effects of atmospheres shown in this diagram have been drawn from data derived by careful experimentation. The usual method has been to place pure materials in a special atmosphere under accurate temperature control and, after equilibrium has been reached, to analyze the atmosphere, examine the materials, and plot the results. This process repeated with different materials and many temperatures and with different gas concentrations has made possible the knowledge we have today. The work has been done mostly by **Baur** and **Glaessner, Boudouard** and **Matsurbara.**

✦ ✦ ✦

THESE investigations present in a concrete form the many changes that take place between a metal and its surrounding atmosphere during heat treatment. Emphasis must be placed upon the fact that these studies represent the conditions that exist when these reactions have reached equilibrium. These changes take place very rapidly, especially at high temperatures, so that for practical purposes they represent very accurately the many conditions that exist.

✦ ✦ ✦

THE following quotations on the general subject of environment are to the point:

"The iron oxygen system has not proved as simple as might be expected. In fact it is amazingly complex; although there are only three authenticated oxides of iron, they dissolve in each other in several series of solid solutions, so that the pure oxides are rarely found."—by O. C. Ralston.

✦ ✦ ✦

"Even the layman can get a vivid realization of the complexities of the problems involved. He has but to walk through the country and note the bewildering play of inorganic colors everywhere about him, ranging from deep brown-black to various shades of drab, brown, purple, maroon and so many tints of pink, ocher and rose, to the most brilliant reds and orange-yellows, and then realize that almost every one of these hundreds of colors is due to an oxide or hydrated oxide of iron."—Quotation from Sosman—taken from Bureau of Mines Bulletin No. 296—"Iron Oxide Reduction Equilibria."

✦ ✦ ✦

The Demand for Controlled Atmospheres

ANOTHER problem of fundamental importance in the heat treatment of metals is decarburization. Generally, decarburization becomes greater the higher the temperature employed, provided the gases of combustion or the atmosphere are such that they support this reaction.

✦ ✦ ✦

NUMEROUS and extensive investigations have been conducted to overcome oxidization and decarburization of steel. In the last few years, particular attention has also been given to clean and bright annealing of ferrous and non-ferrous metals, as well as to carburizing and nitriding of steels. During these developments, it was found that in some cases atmospheres consistent with the products of combustion would meet the requirements, while in other cases, a special atmosphere not consistent with the products of combustion was necessary. It is thus apparent that we have to consider two broad divisions: The effect and results produced by the products of combustion coming into direct contact with the work being heat treated, and the effect and results produced by a prepared special atmosphere surrounding the work.

✦ ✦ ✦

THE application of Gas Atmospheres applies to direct fired furnaces as well as to muffle furnaces, retort furnaces, electric furnaces and radiant tube furnaces.

✦ ✦ ✦

TAKE for instance, the diffusion flame burner. In 1933 we entertained high hopes for the numerous possible applications of this type of combustion. The main objectives were to obtain a high rate of heat transfer to the material being heated and provide a gas blanket for the work, so that scaling of the work could be eliminated.

✦ ✦ ✦

TODAY, after a period during which many applications have been made, we can better bracket diffusion or controlled luminous combustion. We know its limitations, its advantages and how better to employ it for affecting furnace atmospheres. It is one form of preparing a furnace atmosphere. As we progressed with its use, we found that a combination of clear flame combustion and free carbon obtained from the partial cracking of gas and air, when properly employed, resulted in a furnace atmosphere that went far in controlling decarburization and scaling.

✦ ✦ ✦

Control of Free Carbon

THE smoke burner, which is a modification of diffusion or controlled luminous combustion, has many applications in prepared furnace atmospheres. This is valuable particularly in the case of sheets where it has been customary to use a charcoal dip to prevent sticking during rolling. When free carbon is injected into the furnace atmosphere the sheets do not stick together and surface conditions are good, even where a certain amount of air leaks through a poorly constructed furnace wall. In other words, free carbon in a furnace atmosphere offsets the oxidizing condition of a certain amount of air infiltration which otherwise would have caused severe scaling in a non-luminous type of furnace.

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IT has been possible in other cases (for example, in a car bottom annealing furnace) to offset a decarburizing effect by injecting a certain amount of free carbon. In a wire normalizing furnace, See Figure III, where the wire is heated in coils to temperatures around

1900° F., it has been possible to meet the extremely difficult conditions of preventing detrimental scale on the outer strands of the coils and controlling the decarburization.

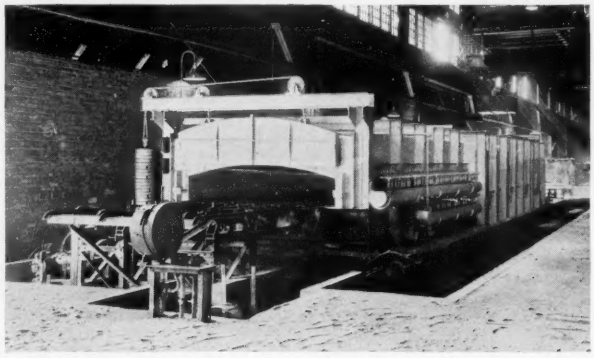

Fig. III. Normalizing Furnace.

THE importance and value of this control of free carbon in furnace atmosphere when handling steel at elevated temperatures cannot be over-emphasized.

✦ ✦ ✦

Development of Radiant Tube Heating

THE application of diffusion combustion to the radiant or glow tube is of interest, see Figure IV. In this case combustion occurs within tubes which radiate heat outward to the work, similar to electric heating elements. The gas and air after leaving the burner flow in parallel layers without encountering any appreciable turbulence. Combustion, therefore, takes place at the boundaries of the gas and air layers and proceeds at a uniform rate until, at the exit end of the tube, all gas has been burned. In this way the heat release is uniform along the length of the tube; furthermore, the rate of heat released is greater than in a duplicate setup using non-luminous combustion. The reason behind this is that in the non-luminous system heat is transferred almost entirely by convection and is proportional to the first power of the difference in temperatures between the work and heat source, while in the diffusion combustion system heat is transferred mainly by radiation and is proportional to the fourth power of the temperatures.

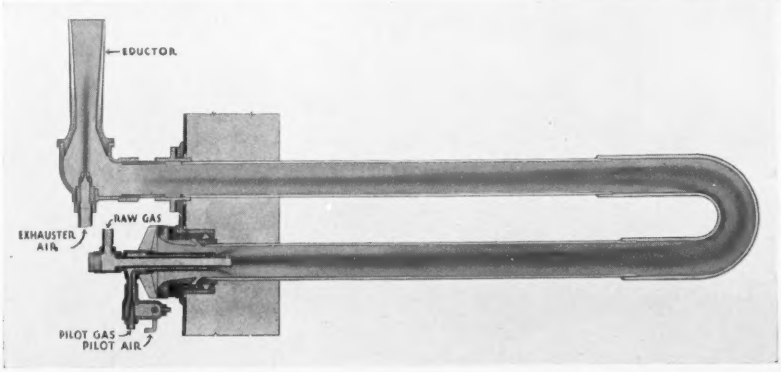

Fig. IV. Radiant Tube Assembly.

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Bright and Clean Annealing of Non-Ferrous Metals

ANOTHER important phase in the heat treatment of metals by controlled flue gases is the bright and clean annealing of non-ferrous metals. It is now possible to bright and clean anneal a large variety of metals in a direct-fired furnace.

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THERE are, of course, many factors which will influence the surface conditions obtained with a controlled flue gas atmosphere. First of all, the surface produced will depend on the materials undergoing heat treatment. While copper, for example, may show bright anneal, brass with the same atmosphere, will only show a clean anneal and steel will show an oxide.

Fig. V. Continuous Open-Fired Bright Annealing Furnace.

✦ ✦ ✦

WHEN bright annealing copper in an open-fired continuous furnace, see Figure V, the general procedure is to bring the work to temperature as quickly as possible, soak it for a definite time interval and then cool in a chamber into which a prepared atmosphere has been piped. The atmosphere must be reducing in character.

✦ ✦ ✦

ON certain quality of material the work can be heated in a direct-fired furnace — spray (steam) quenched, cooling the material to a temperature above the condensation point of steam and then cooling, with a DX prepared atmosphere, to a temperature below the discolorization point of the material before discharging into the open atmosphere.

IN addition to copper, there are metals such as nickel and silver which can be bright annealed in this manner. When annealing steel, brass or other non-ferrous alloys with a large zinc content it was found that the open-fired furnace could not be employed. Instead, it is necessary to anneal these metals in a furnace where the material will not come in contact with the products of combustion and with an atmosphere that has been conditioned before entering the furnace.

✦ ✦ ✦

Normalizing and Spheroidizing Furnaces

THE normalizing, annealing and spheroidizing of wire rod used in the manufacture of cold headed and rolled threaded bolts has been under extensive discussion recently. While there are two lines of thought as to the advantages and disadvantages of a normalized structure versus a spheroidized structure as affecting die life, etc., it is advisable to analyze the different types of furnaces now in use for both types of treatment.

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FIGURES VI and VII show a bell type radiant element heated type of furnace. This type of furnace is applicable to batch type normalizing, annealing or spheroidizing and is so constructed that an inner cover can be employed and if desired a controlled atmosphere can be used.

✦ ✦ ✦

THIS type of furnace is applicable for heating any size coil. The installation shown in Figures VI and VII is being used to treat coils weighing a maximum of 730 lbs. varying in size from 54″ OD x 26″ ID x 8″ high to 44″ OD x 26″ ID x 7″ high.

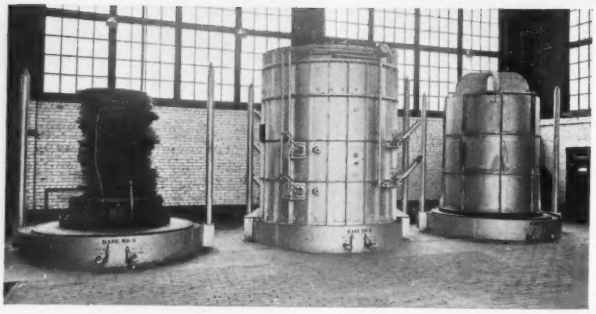

Fig. VI. Bell Type Annealing Cover. ✦ ✦ ✦ ✦

THE method of loading is to stack the coils on a spindle which rests on an alloy base plate to a maximum heighth of 64″ above the plate. The average load is 8 - 730 lbs. coils or 5840 lbs. of wire.

✦ ✦ ✦

AFTER the original heat and with the use of a hot cover and a warm base, it is possible to heat an approximate load of 6000 lbs. of wire rod to a temperature of 1360° F. in 2 hours and 45 minutes. The temperature variation in the vertical height i.e., bottom, middle, and top, at the end of this time is within 10° F. After a 45 minute soak the hot cover is placed over a new load and a cooling cover is placed over the heated coils to permit a control over the rate of cooling.

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THE facts as shown in Figure VIII, are a typical report of a heat by the user of this equipment. The excellent spheroidized structure, obtained through the time-temperature treatment, is shown in the photomicrograph Figure IX.

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THE thermal efficiency of this unit when operating continuously is 37%, which for an indirectly heated furnace can be regarded as good. The cost of gas per ton of wire rod spheroidized will of course depend on the cost of gas where the installation is made but assuming a gas cost of 25c per thousand cubic feet of 530 B.T.U. value, this unit is spheroidizing at a cost of 54c per ton or $.00027 per pound.

✦ ✦ ✦

FIGURE X is of a slightly different type of bell annealing furnace. While like the radiant element heated furnace, in that it has fan circulation, it is heated by a number of direct fired burners arranged around the periphery and in several tiers in the vertical height. This type of unit under identical operating conditions has a slightly higher thermal efficiency than the unit shown in Figure VI and VII. It has the disadvantage of having a scaling or oxidizing effect upon the metal and inner cover unless an alloy inner cover is employed.

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ANOTHER batch type of unit, see Figure XI, is well known in the industry, but which is being replaced by the designs as shown in

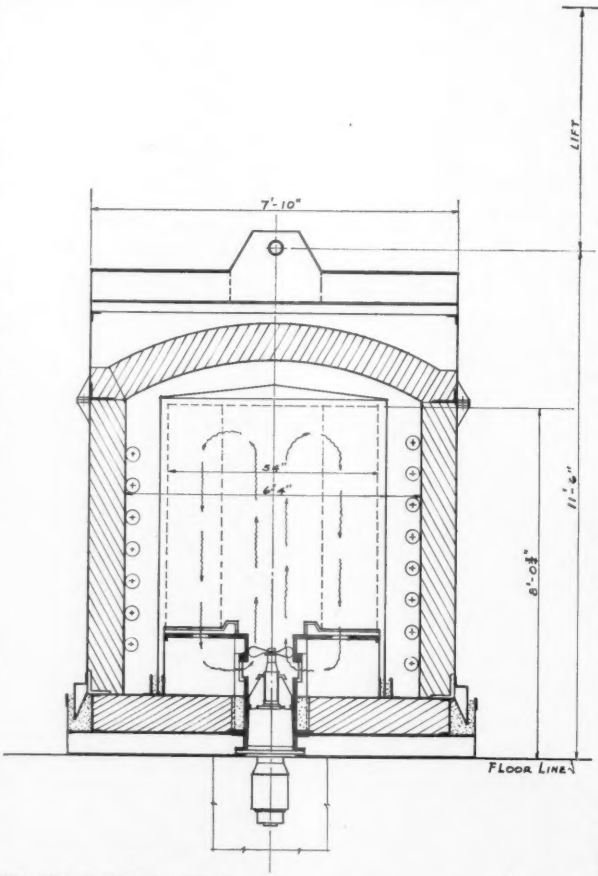

Fig. VII. Bell Type Annealing Cover. ✦ ✦ ✦ ✦

Figures VI and X, is the pit or pot type. While an alloy container or pot can be employed for keeping the wire from the products of combustion and by means of proper spindle design, the lifting stress is partially eliminated from the pot, usually the total gross weight heated is considerably greater than in designs previously described. This results in a higher operating cost. As fan circulation is not employed, the temperature distribution is not as good and naturally the rate of heating is materially decreased.

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CONTINUOUS "normalizing" furnaces as shown in Figures III and XII of the direct heated type produce a high quality of uniformly normalized rod. Due to the continuous flow of material thru the furnace, each coil receives identical treatment in respect to time temperature cycles and is subject to the same atmospheric condition, uniform physical and grain structure results from coil to coil.

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AS is seen in Figure XII, the unit is uniformly heated by means of automatic proportioning gas burners of the low pressure type (see Figure XIII) fired above and below the work. In addition smoke burners discussed early in this paper and as applied have played a very important part in the success of this type of furnace. Without conditioning, the atmosphere caused decarburization and excessive scale resulting in a long pickle time, often etching the rod surface which is not surprising considering the length of time the rod is subjected to a high temperature. See Figure XIV.

✦ ✦ ✦

THE application of atmosphere conditioning (smoke) burners resulted in a very marked decrease in decarburization and in pickling time.

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IT is necessary to establish cycles of heating and cooling to allow the center and the outside strands to increase and decrease in temperature without an excess difference in physicals and grain size. The cycle and temperatures shown in Figure XIV are for normalizing 600 pound coils at the rate of 6,000 pounds per hour.

ANNEALING REPORT

Base No. 2 Charge No. 363 Date—June 9, 1936

Heat No. 83524		Meter at Finish	2620700
Size 19/64" Rd.		Meter at Start	2617100
Weight 5940 Lbs.		Gas Used	3600 x 1.8 (correction factor) =6480 cu. ft. =1.09 cu. ft. per net lb.
Annealing Temperature	1360°		
Time at Start	12:05 A. M.		
Time Heating Up	2 Hrs. 45 Mins.		
Time Soaking	45 "		
Total Time	3 Hrs. 30 "		

Cooling Temperatures After Furnace Removal

1 Hr.	1240°	2 Hrs. 1080°	3 Hrs. 1040°	4 Hrs. 1000°
TIME	1:50	2:50	3:50	4:50

Analysis S. A. E. 1035

Carbon	.38
Mang.	.80
Phos.	.018
Sul.	.025

Physical Results

Percentage of Spheroidization 100%

Fig. VIII. Annealing Report. ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

FIGURE XV, shows photomicrographs of the green and normalized rod and also gives the analysis of the steel and physicals before and after treatment. It will be observed that the normalized structure shows a slightly decarburized surface of approximately .002 deep. Before atmosphere conditioning burners were applied the decarburized depth was several times that being obtained at present.

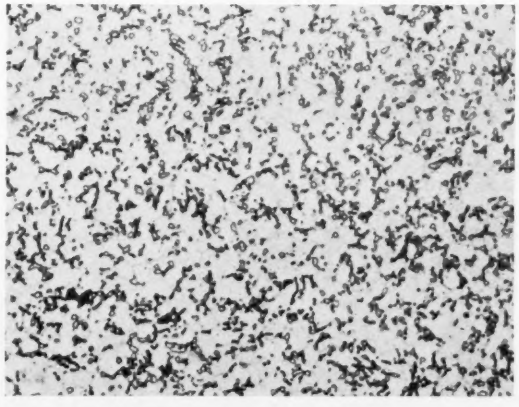

Fig. IX. Spheroidized Rod. S. A. E. 1045 — 500 X. ✦ ✦

✦ ✦ ✦

Patenting Furnaces

IN addition to the furnaces discussed, the patenting furnace, Figures XVI and XVII, is a good example of the importance of heat distribution. Primarily used for the treatment of spring wire and rope wire products it has proved very valuable in the treatment of low carbon products when absolute uniformity of structure is of paramount importance. The unit shown in Figure XVI is 4' wide by 50' long. It is heated by 44 burners of the high pressure automatic proportioning type, (see Figure XVIII) applied from each side and in staggered positions, and is divided into three zones of automatic temperature control. A lead pan at the outlet end permits both lead and air cooling at any time.

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AS we leave the direct fired or heated furnaces and before discussing prepared

atmosphere, we should mention lead pot patenting and double lead pot annealing kettles, and the salt bath, and recognize the clean metal surface resulting from the use of these various methods of liquid heating. The operating costs, while high using a liquid heating medium, often justify themselves when all the factors entering into an intelligent determination of operating costs are considered.

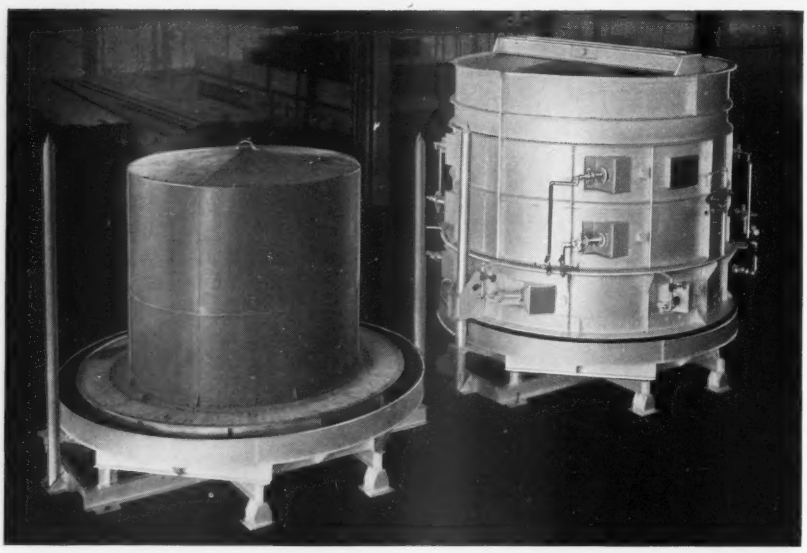

Fig. X. Bell Type Annealing Cover—Direct Fired.

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Occluded Gasses

IT is well known that metals while solidifying from the liquid state have the property of dissolving various amounts of different gases. Oxygen and carbon dioxide are two of the important solubles. Now, the general tendency for such occluded gases is to be liberated while the metal is heated to annealing temperature. Any metal which can be oxidized easily will, therefore, be tarnished by these liberated gases. Brass is such a metal.

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Equipment for Producing Controlled Atmosphere

THE most common of the prepared gas atmospheres, the one finding the greatest number of applications at present, is the end products resulting from burning six parts of air with one cubic foot of natural gas, or the equivalent in other gases. The approximate analysis resulting from burning a 6 to 1 natural gas mixture is:

N_2	74
H_2	9.6
CO	8.7
CO_2	5.8
CH_4	1.9
Specific Gravity	.91

THE gas will be saturated with water vapor at approximately 135°F. The equipment, see Figure XIX, for generating this gas consists of an insulated lined cylindrical combustion chamber in which a proportioning type of burner supplies the gas-air mixture, which has sufficient air to maintain the temperatures necessary for this reaction within the chamber without resorting to any external means of heating. The flue gases thus generated are lead over to a water scrubbing tower in which they are washed and dropped to tap water temperature. From there they are conducted to a refrigerator coil which of itself decreases the moisture content to any degree desirable down to approximately 38°.

Fig. XI. Pit or Pot Type Annealing Furnace.

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Chemistry of Controlled Atmospheres

THERE are a number of factors involved in bright heat treating other than the new atmosphere. This is best proven by the fact that the same gas can be used to oxidize or deoxidize a piece of steel.

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IN all good scientists, however, there prevailed a deep respect for the fundamental scientific data on the action of gases established by their renowned predecessors.

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FOR example, the equilibrium chart (see Figure II) says iron will scale at 1500° when CO_2 reaches a value of 18% less than CO, or when H_2O comes within 16% of the H_2 value. Time and again we came up to the boundary line of these curves. The atmospheres were still none too commercial and even at that the gases, according to the charts, must be so enfeebled when near the equilibrium curve as to be practically useless, and so we started on another track. The development of the Eutectrol process of carburizing and the Methanol process for brass annealing clearly conveyed the fact that it was just as practical to control reactions as it was to try and prevent them. In other words, instead of trying to make a neutral gas which would remain fixed, we should send in a mixture which would react and then control the reactions.

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NOW with this as a premise, what do the equilibrium charts tell us?

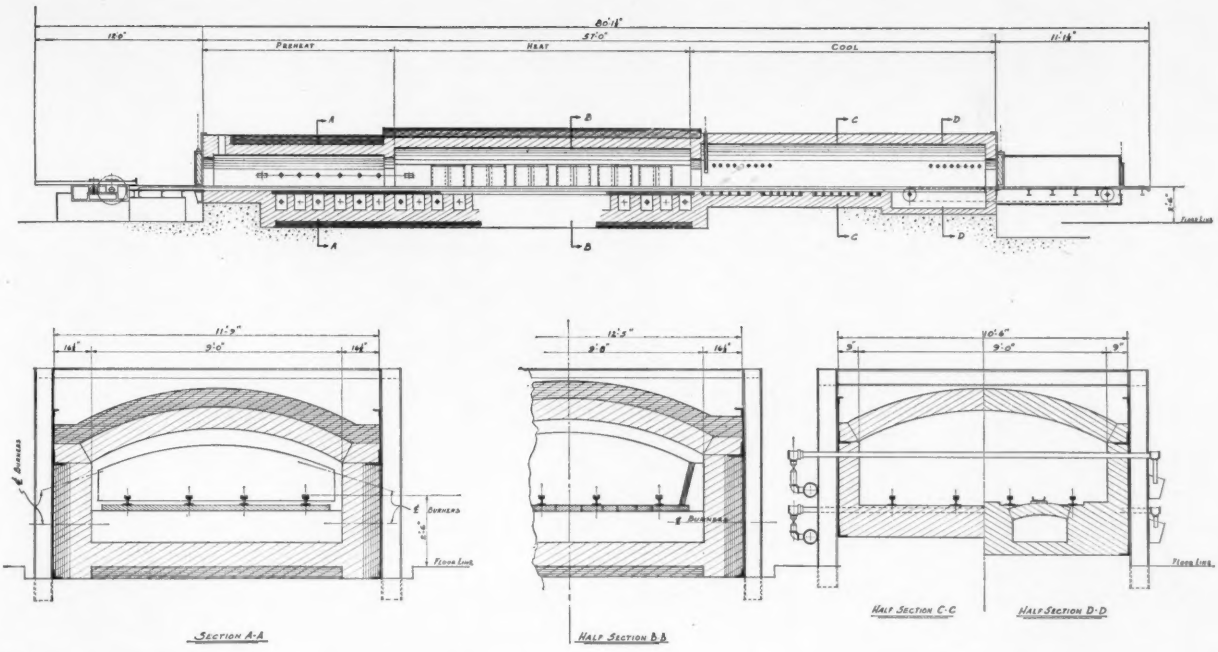

Fig. XII. Normalizing Furnace.

Probably this comparison would not withstand the scientist's attack, but let us take a mechanical example. To an ordinary engine we pump by means of a compressor a correct mixture of air and combustible gas. The kinetic energy of this mixture runs the engine. We can accurately plot a curve showing just how much horse-power the engine will develop for each pressure of the mixture (there is our equilibrium curve). But now we apply a torch to the outside of the cylinder. As the cylinder attains temperature, we begin to get a partial combustion. Right here we begin to leave our curve and we soon reach a point where the combustion is complete and instantaneous and the action on the piston is far greater than the original kinetic energy supplied and the results are clear off the chart. As we cool down we reach a point where the process again comes back to the curve and it follows that accurately from that point down to atmospheric pressure.

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IN some such way the gas atmospheres behave. They will show they went to college and learned their curves up at least to a certain point, but even though they know what is expected of them from there on, nevertheless, when they begin to get hot you might just as well take it philosophically and say "Well, boys will be boys" and join in the fun. You might name the cause of this behavior activated hydrogen, nascent carbon or atomic reactions.

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THE remainder of this discussion is based on the hope that in this case you are more interested in the performance than in the name.

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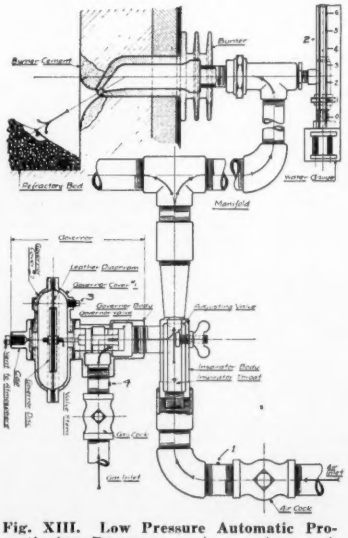


Fig. XIII. Low Pressure Automatic Proportioning Burner.

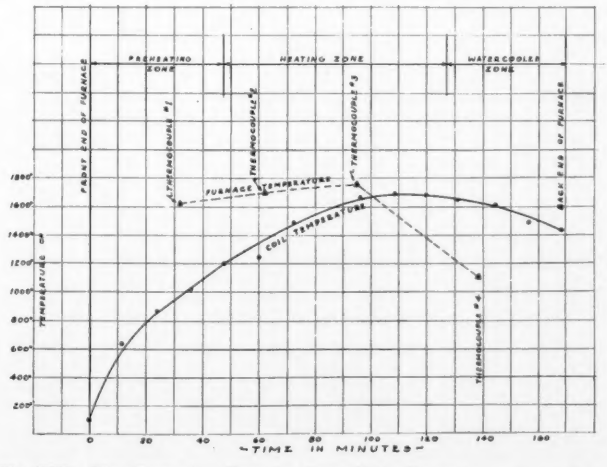
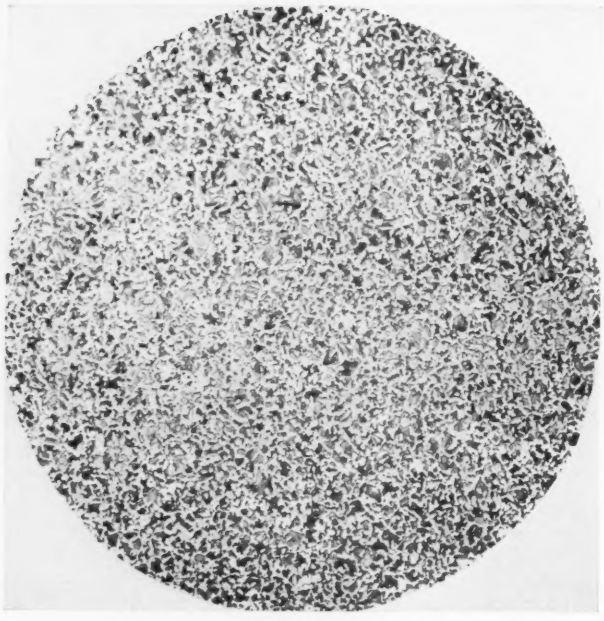


Fig. XIV. Time-Tempering Chart for Normalizing Furnace.

5/16" RODS — NORMALIZING HEAT NO. 1168

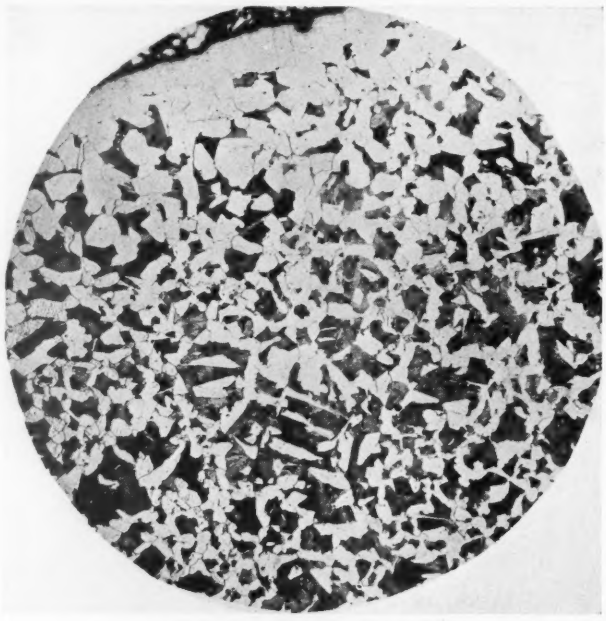
ANALYSIS

	C	Mn	P	S	Si
Ladle	.39	.77	.019	.034	.14
Check	.39	.74	.017	.034	.16



GREEN — 100 X.

Rockwell "B"	77-80
Tensile	89450#
Red. of Area	57.5%



NORMALIZED SHOWING DECARBURIZATION — 100 X.

Rockwell "B"	74-76
Tensile	80890#
Red. of Area	50.2%

FIG. XV.

Mechanics of Controlled Atmosphere

ONE of the other factors involved in the bright heat treating is the sulphur content in the original gas. Natural gas and some butane and propane usually contain sulphur percentages which are not felt. Several years ago while running some bright annealing tests on copper we swung over to the manufactured gas and encountered black stains which would not pickle off. This immediately threw a very serious crimp into the bright annealing program as far as manufactured gas was concerned and we immediately concentrated on ways and means of overcoming this situation. It was discovered that by putting the gas through our DX combustion chamber we had again reformed the sulphur compounds to a form which could be removed easily.

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THE prepared atmosphere gas generated in the DX machine, as shown in Figure XIX, can be a mixture of air and gas from a mixture slightly below the exothermic point to a practically neutral oxygen free gas. The analysis of the prepared gas for different air

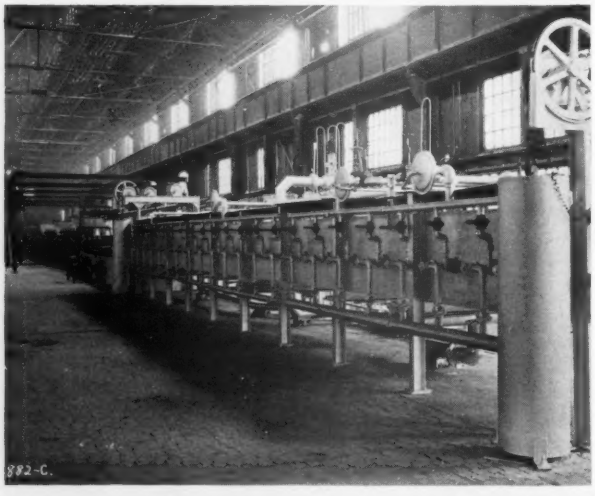

Fig. XVI. Patenting Furnace.

Fig. XVII. Patenting Furnace.

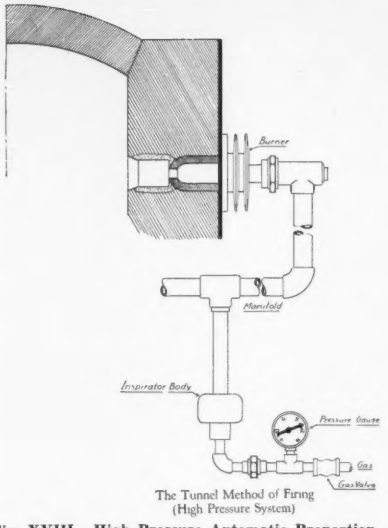

Fig. XVIII. High Pressure Automatic Proportioning Burner.

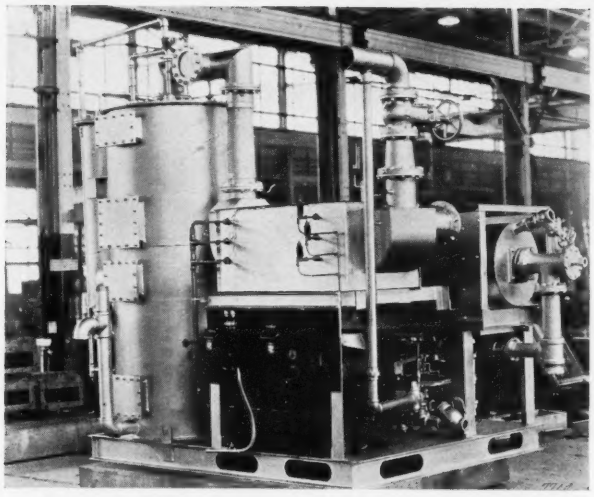

Fig. XIX. DX Machine.

gas ratios is as shown in Figure XX.

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ANOTHER factor which is present in the hardening units, see Figure XXI, which are connected by a sealed chute to the quench, is the vapor from the quench bath. Steam from the water quench will poison the atmosphere to the oxidizing side. Oil will not have the oxidizing effect, but the piece itself is discolored by the oil during its quenching unless extreme care is exercised and the unit in absolute balance, so there is little gained in appearance by bright heat treating prior to quenching.

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THEN, there are other factors which are more or less mechanical. For example, the furnace must be tight. Any flue gas leakage into the muffle or air leakage in from the openings at the end is bound to have a destructive action. It is, therefore, necessary on continuous furnaces to either use some sort of vestibule construction or else to use eductors on the ends and limit the height of the opening. The greater the size of the opening the more the furnace atmosphere gas will be required.

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THE application of DX gas has reduced costs 1/3 to 1/6 of the previous costs. One company reported unofficially that their costs had reduced from 28c to 4c per ton by the use of the prepared DX gas.

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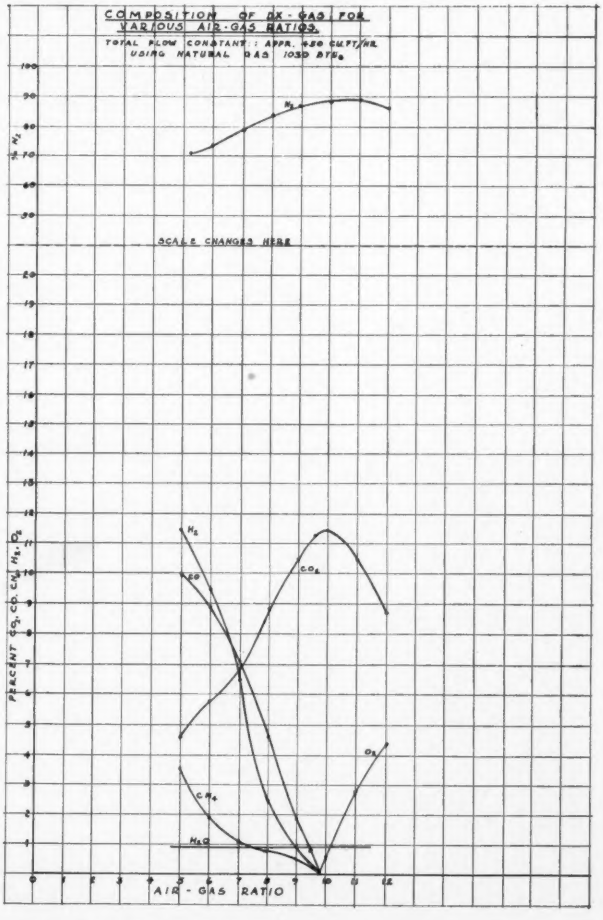
COMPOSITION OF DX-GAS FOR VARIOUS AIR-GAS RATIOS.
TOTAL FLOW CONSTANT: APPR. 450 CU.FT./HR.
USING NATURAL GAS 1050 BTU.
SCALE CHANGES HERE
AIR - GAS RATIO

Fig. XX. DX Natural Gas Curves.

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IT is the fact that this gas will not readily break down at high temperature and is non-explosive that permits it to be used throughout the heating and cooling cycles, excluding products of combustion and air.

✦ ✦ ✦

Variations in Atmospheres

WHILE the gases within the realm of six parts of air to one of natural gas or the equivalent in other gases would probably be suitable for the major applications, there are reasons, however, why the same composition cannot be used as a universal application. These reasons are:

1. **To protect high carbon steel from decarburizing. In this case it is necessary to produce a carburizing gas in equilibrium with the carbon content of steel treated. The six to one ratio would be in equilibrium with approximately a 40 carbon steel.**
2. **It is necessary to run very lean mixtures for the sulphur ladened manufactured gases. In this case about a nine to one ratio is maintained.**

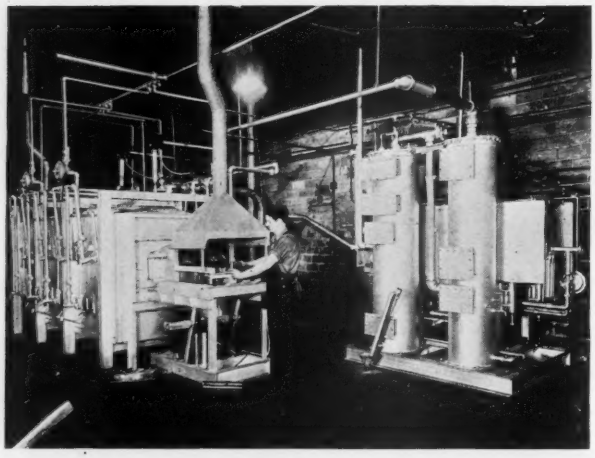

Fig. XXI. Spring Hardening Furnace.

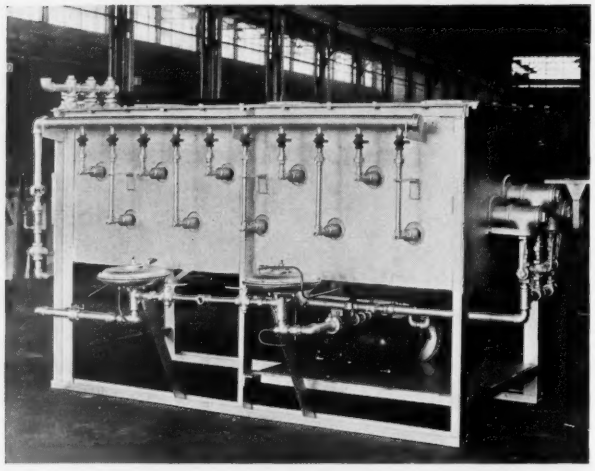

Fig. XXII. CG Gas Preparation Unit.

For brass where methanol is used, also a lean mixture is used of around nine to one. The analysis of this flue gas is approximately:

1%	**CO**
10%	**CO_2**
1%	**H_2**
88%	**N_2**

The addition of methanol CH_3OH breaks down at 850° F and reacts with the above flue gas, the atomic reactions and the products being such as to completely remove the zinc oxides for producing bright brass. The above is a deoxidizing process.

3. To prevent carbon deposition.

✦ ✦ ✦

PREPARED atmospheres for use in maintaining a clean and bright surface on high carbon wire is not as simple an atmosphere to apply as a DX gas to carbon steel up to approximately .35-.40 carbon.

✦ ✦ ✦

USING a CG machine, the CG standing for cracked gas, as shown in Figure XXII, it is possible to make a gas (endorthermic in its preparation) that if applied correctly, and if necessary, further processed can be used for the bright annealing of high carbon material without decarburizing the wire or strip and without having detrimental soot or carbon present.

✦ ✦ ✦

THE various analysis of gases that can be prepared in a CG gas preparation unit is as shown in Figure XXIII. By experimentation and knowing the catalytic reactions that may result from using the different grades of alloy employed in alloy container construction and further depending on the carbon of the steel to be treated, this type of gas can be successfully employed.

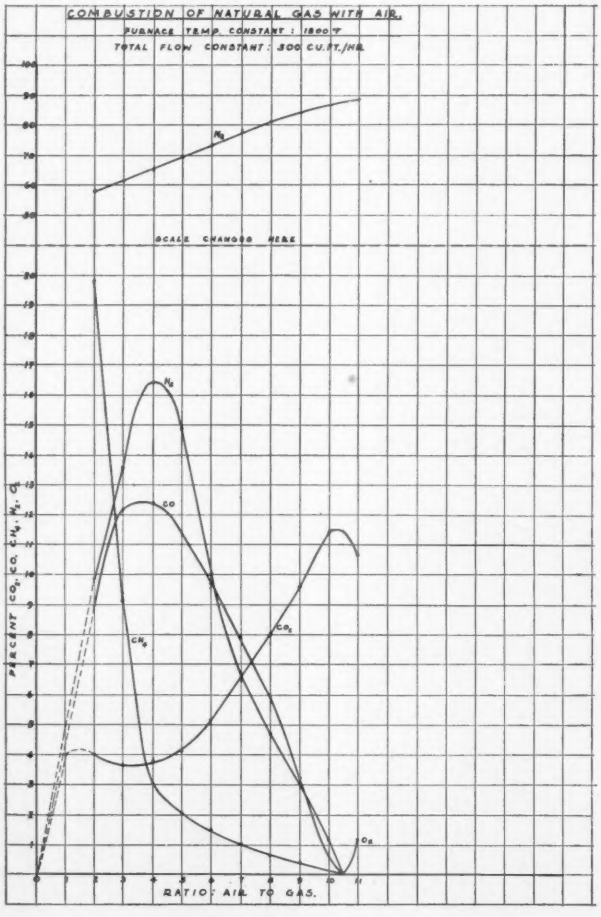
COMBUSTION OF NATURAL GAS WITH AIR.
FURNACE TEMP. CONSTANT: 1800°F
TOTAL FLOW CONSTANT: 300 CU.FT./HR.
SCALE CHANGED HERE
PERCENT CO₂, CO, CH₄, H₂, O₂
RATIO AIR TO GAS.

Fig. XXIII. CG Natural Gas Curves.

✦ ✦ ✦

Bright Annealing High Carbon Steel Wire

RECENTLY a large steel company submitted two coils of cold drawn .80 carbon steel wire .180" RD. for bright annealing. This wire was to be bright annealed in our laboratory and returned to their plant for further drawing, after which it would again be submitted for another bright annealing treatment. This procedure was to be repeated until the samples had been annealed five times.

✦ ✦ ✦

AFTER experimenting with different DX gases, which produced bright work but also with slight decarburization, it was again established that a DX gas could not be used, and a CG gas was selected as a suitable atmosphere. This gas analyzed approximately as follows:

4%	CO_2
0.0%	O_2
15.6%	CO
59.5%	H_2
7.9%	CH_4
17.7%	N_2

FOR the first anneal, see Figure XXIV the wire was placed in an alloy annealing box with a sand seal and placed in a furnace at 1350° F. The box required 45 minutes to come to heat, and it was allowed to remain at this temperature for 90 minutes, at the end of which time the fuel gas was turned out and the box and contents allowed to cool in the furnace for 2½ hours until the temperature had dropped to 840°F. At this temperature the box was removed to the air for more rapid cooling. A flow of 15 C. F. H. of CG gas under .5″ water pressure was maintained through the box for the duration of the operation. The samples were bright except for a carbon stain 1½ inches wide through both coils where cold CG gas struck the hot work.

✦ ✦ ✦

THE annealed samples were returned and drawn down to .155″ Rd., after which they were returned for their second anneal. The procedure for this anneal, see Figure XXV, was the same as for the first anneal except that the annealing temperature was 1300°F. instead of 1350°F. These samples came out bright and were returned to the steel company where they were drawn down to .125″.

✦ ✦ ✦

THE same annealing practice was again followed for the third anneal, see Figure XXVI, as for the previous anneals, except that the temperature was reduced to 1250° F. The work came out satisfactorily except that one coil had a slight fog. There was no decarburization. These samples were again returned and were drawn down to .099″ Rd.

✦ ✦ ✦

THE fourth anneal, see Figure XXVII, followed the same procedure as the third anneal. The annealed work had a general silver-gray fog covering it which suggested a small air leak in the annealing box. The samples were nevertheless sent back to the mill for further drawing.

✦ ✦ ✦ ✦

THE samples were drawn down to .078″ Rd., and returned for their fifth and final anneal, see Figure XXVIII. The temperature for this final annealing was reduced to

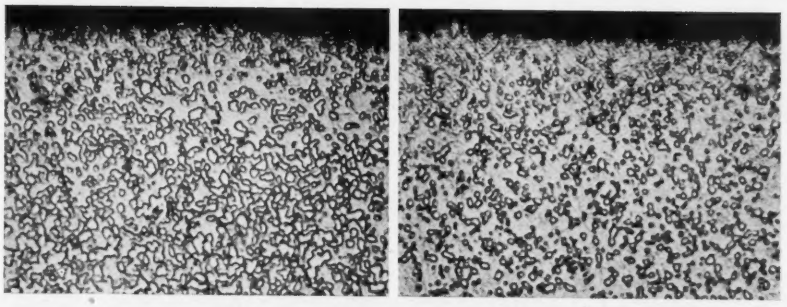

Fig. XXIV. .180″ Round — 500 X. Annealed 1½ Hrs. at 1350° F. ✦ ✦ ✦ ✦

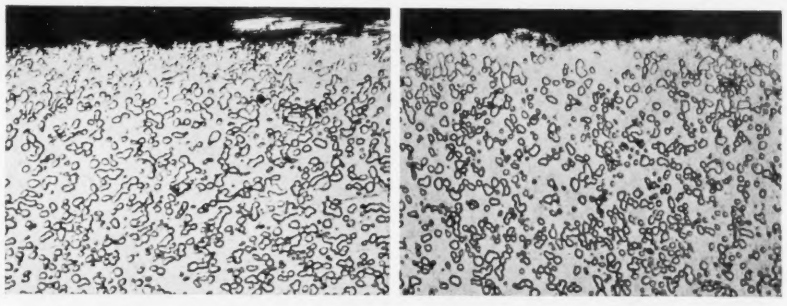

Fig. XXV. .155″ Round — 500 X. Annealed 1½ Hrs. at 1300° F. ✦ ✦ ✦ ✦

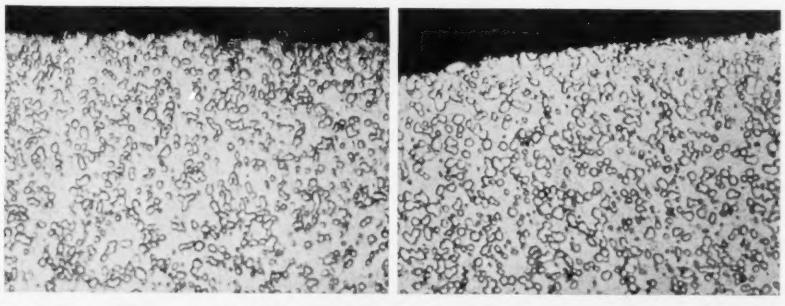

Fig. XXVI. .125″ Round — 500 X. Annealed 1½ Hrs. at 1250° F. ✦ ✦ ✦ ✦

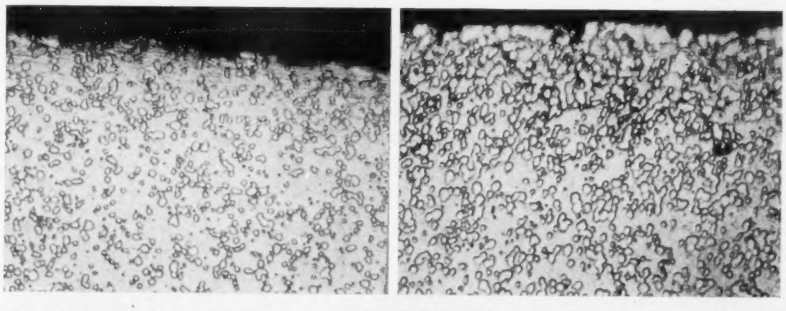

Fig. XXVII. .099″ Round — 500 X. Annealed 1½ Hrs. at 1250° F. ✦ ✦ ✦ ✦

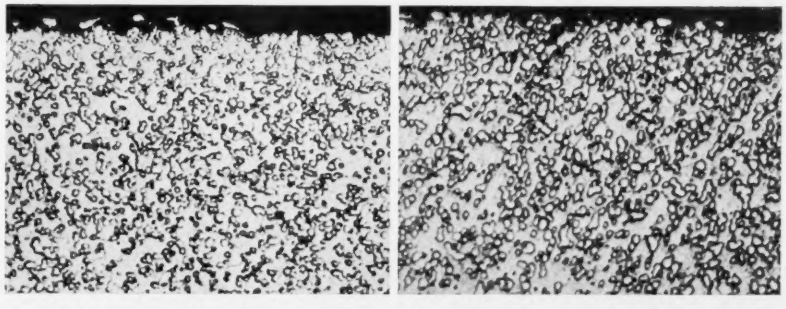

Fig. XXVIII. .078″ Round — 500 X. Annealed 1½ Hrs. at 1200° F. ✦ ✦ ✦ ✦

1200° F., the time at heat and general practice remaining the same as for previous anneals. From this anneal the work came out with a silver fog, but its appearance compared favorably to the appearance after the fourth anneal. A longer time at 1200° F. and a slower cooling would have probably produced cleaner work but it was feared that the longer anneal might appreciably affect the physical properties.

✦ ✦ ✦

THE photographs, Figure XXIV to XXVIII, at 500 diameter magnification illustrate the effect of the annealing treatments and also the lack of decarburization. These pictures were in all cases taken of the cross section of the wire.

✦ ✦ ✦

Future Acceptance of Controlled Atmosphere Furnaces

WE have reviewed in general the application of gas atmospheres, to direct fired furnaces and prepared gas atmospheres to indirect heated furnaces as applied to ferrous and non-ferrous material, but the value of any process or equipment must be expressed ultimately in the cost to produce per unit quantity of work. The value of controlled atmosphere furnaces to industry and the factors which determine their decisions are in the embryo or making today. In the various industries, the deciding factors in making this determination will vary. In some industries operating costs are of first consideration and in other industries, the quality of product, and in still other industries, the sales appeal or merchandising value that can be gained from the use of atmosphere units in preference to the conventional direct-fired types.

✦ ✦ ✦

THE last ten years' experience in the modern direct-fired type of furnace has taught industry that by use of the modern direct-fired type of furnace they were able to accomplish lower operating costs and a quality of product that prior to the development of the modern direct-fired furnace was thought impossible. By controlling the atmosphere in a direct-fired furnace, by allowing the proper time temperature cycle, by the building of an alloy machine within a brick casing and by the proper application of heat, manufacturing costs were reduced. Industry found that they did not have to leave as wide a limit of machine tolerances, in the material to be finished from the heat treated stock as they did before the acceptance of the modern direct fired continuous units. The factors that caused industry to slowly but definitely accept the modern type of direct-fired furnace will slowly but definitely cause them to accept prepared and controlled atmosphere furnaces for many heating and treating operations.

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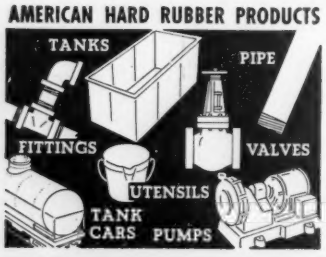

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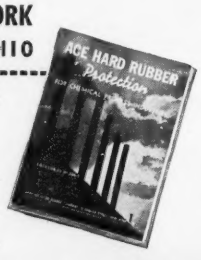

The Selection of Wire Spring Materials

By J. W. Rockefeller Jr.,
Consulting Engineer, New York, N. Y.

A discussion of the more important considerations in the selection of spring making materials including the following steel wires: music wire, annealed steel, hard wire, alloys—Cr.-V, Si-Mn, etc., and a further discussion on the non-ferrous alloys, monel metal and phosphor bronze, in this connection. ✦

THE manufacturer of wire springs has a great many problems in common with the manufacturer of the wire that goes into such springs and if gratifying results are to be obtained it is necessary that the closest cooperation be exercised on the part of both. In many cases the spring manufacturer draws his own wire, but more often he depends upon a wire mill for his material. This is particularly true in the case of some of the more accurate types of springs, such as instrument springs, in which, while the market is substantial, the tonnage is not great enough to justify the operation of a wire mill for this product alone.

✦ ✦ ✦

Considerations in the Selection Of a Wire Spring Material

AT the very outset, it should be emphasized that one of the more important considerations in the selection of a spring material is the reliability of the mill that turns it out. Chemical, microscopic and spectroscopic examination of the product will tell the spring maker a great many facts about material; a first hand acquaintance with the process of manufacture will enlighten him further, but in spite of the long steps taken in the scientific approach to the examination of spring materials, we are still far from the stage where such selection has become an exact science. It is a comparatively easy matter to obtain any chemical analysis and microstructure specified, it is exceedingly more difficult to obtain a spring steel that is absolutely uniform and free from impurities and surface defects.

✦ ✦ ✦

IN the case of most spring material, the subsequent operations upon it, consist of coiling and perhaps drawing or blueing. In many instances however, the characteristics of a spring wire may be materially modified in the shop of the spring maker. The material may have its chemical composition altered in the outer layers (the most vulnerable area) by decarburization, oxidation (usually accidental) or by case hardening (sometimes accidental but often a well defined operation in spring manufacture). Pickling or plating may cause hydrogen embrittlement, not inherent in the material as it left the mill. Thermal treatment will cause a decided change in grain structure, and cold work exerts a marked influence upon the properties of the material. Indeed in more than a few cases it would be difficult for the wire mill to recognize its own product after the spring manufacture has put it through the many operations necessary for the production of some types of springs.

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Graduated from Massachusetts Institute of Technology 1921. 1921-1928, John Chatillon and Sons, New York, N. Y., from which resigned as Works Manager to enter consulting field. Has been engaged in installation of spring plants and design and production of wire springs for firms in spring, spring balance, and automotive fields. Charts for calculation of helical springs, translated into Kilo-Cm basis and adopted by Italian Engineering Standards Committee, 1926. Secretary of Spring Research Committee of American Society of Mechanical Engineers for five years and during that time representative of American Society for Steel Treating on that committee.

✦ ✦ ✦

THE selection of a spring material may become a problem to the spring maker and may take the form of discovering a material that will serve satisfactorily under certain service conditions, regardless of price, or it may resolve itself into the finding of a material that will serve the purpose of a more expensive material at a saving in cost of raw material or manufacture. To illustrate the latter, it is customary in the manufacture of scale springs, to use an annealed wire which is heat treated after coiling into springs. In the cheaper forms of straight spring balances, the manufacture of the spring itself represents a large item in the total cost of the article. In the case of some cheaper straight spring balances it has been found that music wire could be substituted providing the spring was coiled with no initial tension, and a material saving has thus been effected. Music wire, of course, is one of the more expensive spring materials, but music wire is relatively cheap when compared with the cost of some instrument springs. So low grade a material as ordinary Bessemer wire is sometimes used for wire forms where a slight spring action is required, and while such material is not usually included in the category of spring steels it serves quite satisfactorily in many such instances, where the utilization of a more expensive product would not be justified.

✦ ✦ ✦

EVEN if the matter of cost is left entirely out of the spring maker's determinations, there is no spring material that can be considered best for all springs regardless

of type or the duty they must perform. In most cases it is desirable that the spring material will be such as to allow many flexures, but in rare cases, it is desirable that it fracture completely the first time it is used.

✦ ✦ ✦

EVEN when the desired properties are well known, spring materials of the same chemical analysis and microstructure will show decidedly different results in laboratory tests. Laboratory tests on test specimens may not bear a definite relation to laboratory tests on finished springs coiled from the material from which the test specimens were taken and, lastly, field tests upon finished springs may not reflect truly the properties that might be expected in the light of laboratory tests.

✦ ✦ ✦

Principal Spring Materials

IN view of the foregoing, it will be apparent, why the following list of spring materials should be used as a guide only. They all have their uses and the brief description of each material will indicate in a general way what such uses are.

✦ ✦ ✦

Bessemer Wire

THIS wire is drawn of steel made by the Bessemer process. Strictly speaking it is not a spring steel, but due to the cold work it receives in drawing it has some spring properties and is used occasionally for wire forms where a slight spring action is all that is required. The sulphur content is too high for the wire to have any toughness and its elastic limit is low. However, it is the cheapest of all materials described in this article.

✦ ✦ ✦

Hard Drawn Spring Wire (Premier or Crown Spring Wire)

THIS usually has the following analysis, Carbon .50 to .65%, Manganese .70 to 1.00%, Silicon .10 to .20%. It obtains its strength through cold work it receives in drawing to size. The process of manufacture, briefly, is cold drawing an open hearth steel from hot rolled rods after they have been suitably annealed. A carefully controlled heat treatment known in the trade as patenting leaves the wire in a sorbitic condition. After the patenting the wire is drawn to size through dies during which process it obtains its strength. Small diameters of this wire will have a tensile strength of from 200,000 to 300,000 lbs. per sq. in. and the elastic limit will ordinarily be from 120,000 to 180,000 lbs. per sq. in. although this is not well defined, the stress strain diagram of this material showing a very gradual departure from the approximate straight line as the elastic limit is approached. In some spring applications this is a decided disadvantage while in others it would not be so considered. In forming this material, it may be made to take a fairly sharp bend without fracture and its low cost recommends it for the general run of helical springs. When helical extension springs are coiled of this material they have an initial tension between coils which cannot be held absolutely uniform and for this reason the load deflection characteristics of two springs of the same lot are likely to show some variation.

✦ ✦ ✦

Music Wire

MUSIC wire is produced in much the same manner as hard drawn spring wire except that it is made in smaller diameters and usually a higher grade rod is used, —sometimes electric steel (Some manufacturers use only the highest grade electric steel for this product while others use an acid open hearth as well.) The manufacture including drawing and patenting are more carefully controlled. The carbon content is higher (.70 to 1.00%) and the manganese lower (.25 to .40%). During the drawing of this wire it is given a light plating of copper and finally one of tin which serves to lubricate its final passages through the dies. The result is a bright finished wire of very high tensile properties. Wires of this material in diameters of .005 in. have withstood stresses of more than 500,000 lbs. per sq. in. before breaking. Music wire is the strongest material for volume of any known to engineers and as such has been the object of wide investigation on the part of spring manufacturers as well as others interested in its application. Basing their calculations on the extrapolation of empirically derived formula, investigators in this field have predicted that were it possible to draw this wire to the required fineness, it would stand stresses of over 1,000,000 lbs. per sq. in. In diameters of .100 in. the ultimate strength is in the neighborhood of 250,000 lbs. per sq. in. increasing as the diameter of the wire decreases until at .005 in., as noted above it exceeds 500,000 lbs. per sq. in. The elastic limit is not well defined but in the case of coiled springs it is usually raised by subjecting the finished springs to a drawing or "blueing" treatment which brings it to a point very close to the ultimate strength of the material. Music wire is used for springs in smaller sizes where high stresses are to be met. It is more expensive than ordinary hard drawn wire but can be used for purposes where such wire would not stand the stresses imposed.

✦ ✦ ✦

Oil Tempered Spring Wire

THIS wire has a somewhat similar composition to hard drawn spring wire except that it runs somewhat higher in carbon content (.60% to .70%). Ordinarily it is made of basic open hearth rods which are cleaned, annealed and drawn to the desired size wire. This wire unlike hard drawn wire receives its strength through heat treatment rather than cold work and consequently no attempt is made in the drawing to produce a high tensile strength. After being drawn to size the wire is given a spring temper by quenching and tempering in an oil or lead bath. This wire has properties somewhat similar to hard drawn wire except that elastic limit is higher and more clearly defined. On the other hand it does not exhibit the toughness found in springs made of hard drawn wire.

✦ ✦ ✦

Annealed High Carbon Wire

THIS wire is used in very high grade springs and requires more operations in the shop of the spring maker than any of the wires discussed above. Its Carbon content may vary from .85% to

1.00%, while Manganese runs from .30% to .45% with Silicon from .10% to .20%. It is manufactured from electric or open hearth rods which are annealed and cold drawn to size. The wire is supplied to the spring maker in the state of anneal he may specify either with slight temper or dead soft. Springs coiled of this material must be heat treated after forming and are sometimes given a higher carbon content in the outside layers of the wire by case hardening during heat treatment of the coiled spring. The tensile strength of this material after heat treatment runs from 250,000 to 350,000 lbs. per sq. in. The elastic limit will run from 150,000 lbs. per sq. in. in the larger sizes to 250,000 lbs. per sq. in. in the smaller diameters. This wire is used extensively for valve springs and scale springs. In the latter application it has the advantage of being suitable for the production of close coiled helical extension springs with no initial tension between coils. Such springs will possess a load deflection characteristic that is for all practical purposes a straight line and there will be very little variation in the load deflection characteristics of any two springs from the same lot.

✦ ✦ ✦

Hot Rolled High Carbon Steel

THIS steel has a carbon content of from .90% to 1.05%. It is made of either electric or acid or basic open hearth steel and is formed into springs while hot. Its ultimate strength is approximately from 175,000 to 195,000 lbs. per sq. in. and elastic limit from 120,000 to 140,000 lbs. per sq. in. It is used for springs that are too large to coil cold, also for large leaf springs. Springs made of this steel are usually the lowest priced of all springs in cost per lb. but the market for them runs into considerable tonnage. Such springs are produced by a number of the steel companies as an outlet for their product and also by spring companies which specialize in this type. Springs of this general type may be of alloy as well as straight carbon steel the method of manufacture may be very crude or well controlled resulting in a marked difference in the quality of the products of two spring manufacturers using the same general type of steel.

✦ ✦ ✦

Alloy Steels

ABOUT the time that this country was engaged in war with the central powers of Europe, alloy steels began to displace straight carbon steels in a very serious way. It should be recalled that at that time many spring makers as well as other manufacturers of thermally treated metal products were dependent upon the so called practical heat treater who operated without the aid of pyrometer or other instrument and whose judgement of furnace temperatures, as indicated by actual check against recording instruments frequently proved to be something short of perfection. One of the chief advantages of alloy steels at that time was their ability to stand abuse in the process of thermal treatment without showing the effects of such treatment to the extent indicated by carbon steels. Today the story is somewhat different. It is a very unusual spring maker who places his entire faith in the eye of the practical heat treater. Pyrometers are as much a part of the present spring shop as the coiling machines and the furnaces themselves. Still there is a place for alloy steels in spring making and a very important place. Generally speaking, the advantage of an alloy steel over straight carbon steel is more pronounced in the larger sizes than in the smaller sizes of wire, also more marked in the case of springs which are difficult to heat treat with absolute uniformity as compared with those the uniform heat treatment of which is a simple matter. In many instances the case of alloy steels is not conclusively proved while in others such as the manufacture of springs for operation at elevated temperatures or under corrosive atmospheres there is no question but what certain ferrous alloys are to be preferred to springs of straight carbon wire regardless of its purity or uniformity. Some of the alloy steels most frequently used in the manufacture of springs are briefly described.

Chrome-Vanadium Steel

CHEMICAL composition is Carbon .45%-.55%, Manganese .50%-.80%, Silicon .10%-.20%, Chromium, .90%-1.20%, Vanadium .15%-.20%. This steel is usually made in the electric furnace and supplied to the spring maker either in the tempered or annealed condition, in which latter case the springs are heat treated after forming. Ultimate strength will run from 200 to 300 lbs. per sq. in. with the elastic limit from 160 to 250 lbs. per sq. in. It is frequently used for valve springs and in other cases of repeated stressing. It possesses advantages over straight carbon steel under conditions of elevated temperatures. It has been successfully substituted for straight carbon steel in the case of scale springs where frequent breakage at the base of the hook was encountered, its toughness overcoming this condition.

✦ ✦ ✦

Silico-Manganese Steel

COMPOSITION Carbon .50%-.65%, Manganese .75%-95%, Silicon 1.80%-2.10%. This wire is made of basic electric steel and supplied to spring maker either in tempered or annealed condition. When furnished in the annealed condition the spring maker treats the springs after forming. The ultimate strength of this steel will ordinarily vary from 200,000 to 250,000 lbs. per sq. in. and its elastic limit from 150,000 to 180,000 lbs. per sq. in. It is frequently used in springs which are subjected to fatigue conditions.

✦ ✦ ✦

Rust Resisting Steel

COMPOSITION—not over .12% Carbon, Chromium 17%-20%, Nickel 8% to 10%. This steel is especially designed for use where a straight carbon steel would deteriorate rapidly due to corrosion. It is made in the electric furnace and hard drawn, after which it is coiled into springs by the spring maker. An annealed steel of this type but running higher in carbon content (usually from .30% to .40%) is available for coiling springs which are to be subsequently heat treated. Stainless steel springs are

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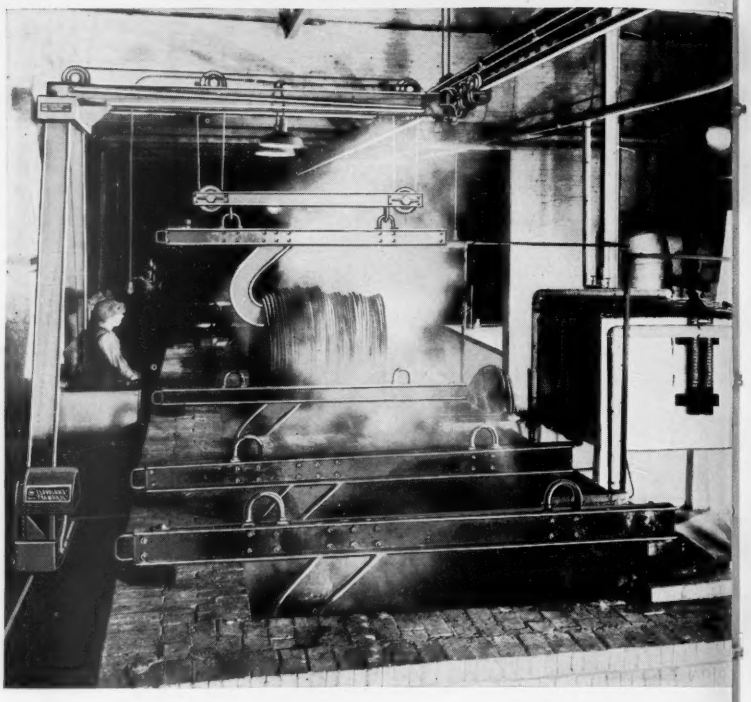

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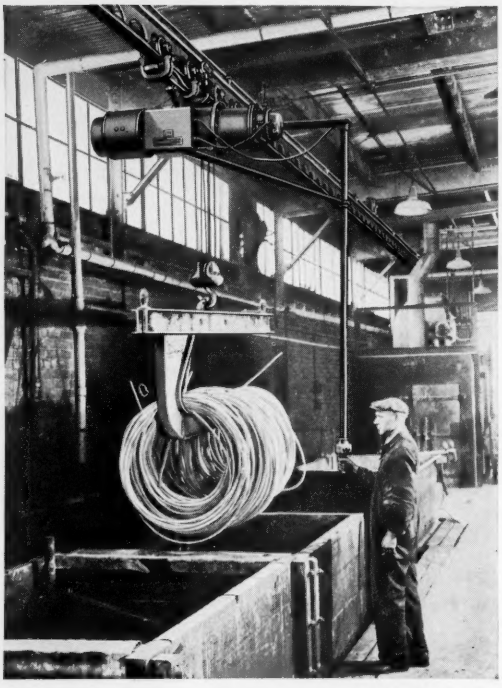

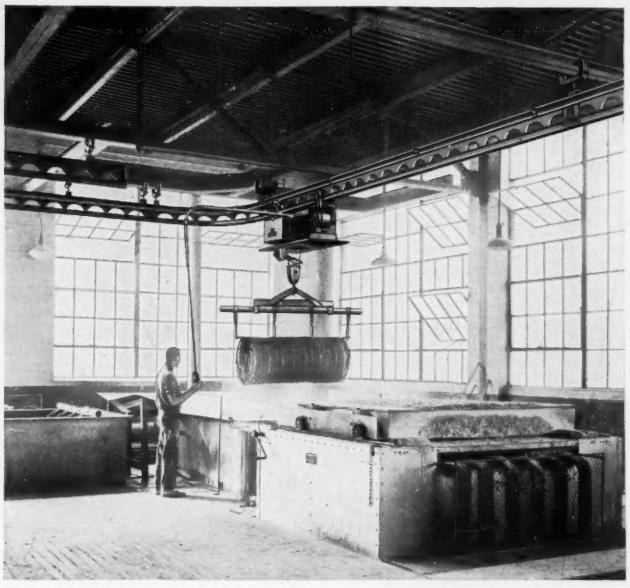

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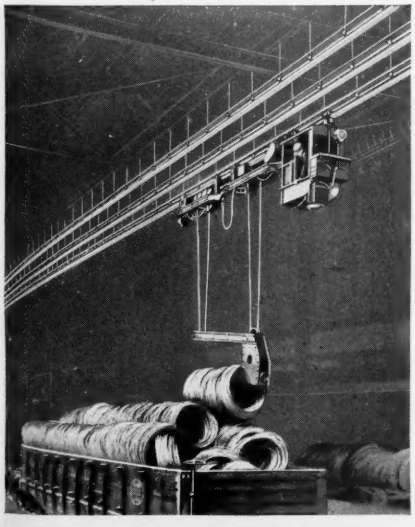

Car loading and unloading

•

Through bakers without rehandling

•

Continuous drawing direct from Hair Pin Hook

•

Block Stripping

•

Various handlings in the Galvanizing and Processing rooms

•

Storing and loading of finished products

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DIVISION OF
THE CLEVELAND CRANE & ENGINEERING CO.
WICKLIFFE OHIO

used under conditions which are highly corrosive and also under high temperatures since they retain their strength under load up to and beyond 700° F. When the annealed steel is used, the subsequent heat treatment depends upon whether it is desired to bring out the optimum corrosion resisting or heat resisting properties. The ultimate strength of this steel is from 150,000 to 280,000 lbs. per sq. in. and the elastic limit from 75,000 to 150,000 lbs. per sq. in.

✦ ✦ ✦

Non-Ferrous Alloys

TO the spring manufacture, it must seem at times as though some one at some time has attempted to alloy almost every element in the periodic table with every other element in the hope of producing a material that can be used for springs. Between the time this article is written and appears in published form it is altogether possible that a new alloy will have been developed that, according to its proponents, is superior to any other material for the manufacture of springs to meet certain conditions. It was not so very long ago that we were informed through some sources that molybdenum would do about everything that tungsten would do and do it better and at a lower cost. We have learned, many of us only after making tests of our own, that this was not the case. It does not follow that there is not a well defined place for this useful element in present day metallurgy. It is simply a fact that excessively broad claims for a material, whether such claims are based upon chemical composition, methods of manufacture or geographic point of origin are more likely to produce cynicism than a warm welcome upon the part of the spring manufacturer or the ultimate spring user. When a spring manufacturer furnishes his customer with a shipment of springs, his design and material recommendations are lost sight of in the light of the actual performance of the springs comprising such shipment. If the maker of the springs recommends that a fibre stress of 80,000 lbs. per sq. in. should not be exceeded and the springs are subsequently stressed up to 120,000 lbs. per sq. in. without serious breakage, it is the latter figure that the user of the springs will bear in mind on future specifications. The failure of subsequent shipments at a correspondingly high stress is sure to cause trouble for the manufacturer, in spite of the fact that he is not to blame.

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SIMILARLY, one batch of wire may be of such uniformity as to permit meeting very close tolerances, while subsequent shipments from the same mill may make the conformation to the same tolerances absolutely impossible. When a recently developed alloy is barely out of the experimental stage the chances of obtaining an absolutely uniform product are much smaller than in the case of a material that has been employed for many years. The spring manufacturer is aware of this and is frequently unwilling to gamble his reputation with his valued customers on such a risk. In the case of some recently developed alloys, I have seen one shipment of wire come off the coiling machine in as perfect a coil as could be wished and a subsequent shipment vary as much as 100% in coil diameter. Every spring maker is familiar with the difficulties likely to be encountered in designing springs of some of the non-ferrous alloys, due to variation in elastic modulus.

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IT should not be concluded from the foregoing that a policy of adhering too closely to well established materials is advocated. If, for example, a spring material could be developed which would combine the high tensile strength of music wire, the fatigue resisting properties of some of the ferrous alloys and the non-corrodability of phosphor bronze, a great many of the spring makers' problems would be solved. The development of any new useful material is usually the result of at least a dozen attempts before a single successful result and the spring maker may be expected to make his contribution in the research necessary for such development. As far as the use of non-ferrous alloys for spring making is concerned, we are somewhat less familiar with them than with steel and can therefor afford to take less for granted. A list of some of non-ferrous alloys which are more commonly used in the manufacture of wire springs follows:

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Phosphor Bronze

COMPOSITION usually 5% tin, 95% copper with traces of Phosphorous, the Phosphorous being added as phosphor tin as a scavanger to remove oxygen and prevent brittleness in the finished product. Phosphor bronze is used as a spring material under conditions that would result in the rapid corrosion of steel. Its elastic modulus being about half that of steel gives it a greater resilience than its elastic limit would indicate when compared with that of spring steel. Its ultimate strength is in the neighborhood of 95,000 lbs. per sq. in. and its elastic limit about 50,000 lbs. per sq. in. for No. 8 B.&S. gauge. This wire receives its strength through cold drawing and in larger diameters the ultimate strength is lower.

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Spring Brass

COMPOSITION 70% copper, 30% zinc. Like Phosphor bronze, this material obtains its strength through cold drawing. Its elastic limit is somewhat lower than that of phosphor bronze and it does not possess the corrosion resistant properties. For this reason it has been largely replaced by phosphor bronze although its cost is considerably lower.

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Monel Metal

COMPOSITION 70% copper, 30% nickel. As a spring material monel metal is a comparative newcomer, but has made a definite place for itself. Its elastic modulus is between that of steel and phosphor bronze with its ultimate strength about the same as the latter. It possesses advantages over both phosphor bronze and brass where abnormally high temperatures are encountered and ap-

(*Please turn to page 592*)

Steel For Arc Welding Electrodes

By R. Notvest, Chief Engineer, Welding Div.,
J. D. Adams Company, Indianapolis, Ind.

Vital metallurgical characteristics of drawn wire to be used for arc welding electrodes. The author endeavors to show that the requirements are entirely different due to the super-heating of the metal and quick freezing of the same when utilized as arc welding electrodes.

IN the sense of this pearl of old Roman wisdom, "Intellegamus Parvum de omnibus unum excellenter", the author considers it his task to present to the technicians of the steel industry not only the view point of the welding engineer, but also the essential requirements which enable the utilization of the arc welding process as a practical fabrication tool and to point out how and where the metallurgy of arc welding presents a radical departure from the technique and the physical and chemical phenomena with which the steel producer is well acquainted from his own practice.

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THAT the consumption of steel in form of arc welding electrodes has reached a tonnage value which now equals or slightly exceeds that going into rivets is very poignantly shown by the tabulation of electrodes sold to agents and consumers in the U. S. during the month of June in 1932, 1935 and 1936 as compiled from the statistics of the Arc Welding Section of N. E. M. A.

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THE following deductions may be drawn from the trend disclosed in this compilation. The proven higher physical results in fusion metal produced under shielded arc conditions, especially ductility, impact value and corrosion and fatigue resistance as compared with those of fusion metal made with bare or light-coated electrodes, will cause a further substantial reduction in the use of the latter type. This also means that the production of shielded arc electrodes will tend to fall into the hands of specialists equipped and experienced to meet the specific requirement of the shielded arc process and will automatically stop this crime of the past where even a hardware store felt perfectly competent to cut coiled mild steel wire into suitable lengths, bundle the pieces, and sell same as arc welding electrodes. Notwithstanding the fact that the skill of the electrical designer has produced arc welding machines of sufficient electro-dynamic stability to meet such essential welding characteristics as quick arc recovery under short circuit with correspondingly low current overshoots, steeply drooping volt ampere curves over the entire available welding range with regulation in fine steps, high overall efficiency and power factor with low temperature rise under load in sizes up to 800 and 1000 ampere, 40 volts, NEMA rating (such machines are capable of burning ½, ⅝, and ¾ inch diameter shielded arc electrodes); the $\frac{3}{16}$ and ¼ inch diameter shielded arc electrodes show maximum consumption, the $\frac{5}{16}$ inch size shows a sharp reduction and out of a total of 6,932,978 lbs. of shielded arc electrodes sold in June 1936, the ⅜ inch diameter size accounted for an insignificant 69,000 lbs. This as will be explained later on is due to the metallurgical injury caused by high current densities (600 amperes or more) which more than offset the advantage gained through a higher deposition rate.

R. NOTVEST

Born in Alsace. Came to the United States in 1909. Originally an electrical engineer, but changed his mind and studied metallurgy at the Morley Chemical Laboratory of Western Reserve University. Engaged in study of arc welding from 1924 to 1929. From 1929-1936 Engineer, Welding Division, J. D. Adams Company, Indianapolis, Indiana.

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WHILE there is a certain small amount of arc welding done on non-ferrous metals such as copper, aluminum, the various bronzes, stainless and manganese steel, nevertheless for quite some years to come the predominant volume utilization of this process will be on the fabrication of plain carbon and low alloy content—high physical property steel. It cannot be emphasized too strongly or repeated often enough that essentially arc welding fusion metal is nothing but cast steel, produced at highly elevated temperatures under very disadvantageous conditions and at that as shown from tabulation (illustration No. 1) the physical characteristics of shielded arc fusion metal compare favorably

(Note—B1 etc. in text refers to bibliographical reference given at conclusion of paper.)

Weight in pounds

Electrodes sold to Agents & Consumers (N.E.M.A. statistics)

Diameter		Bare in Coils	Bare straight cut to length	Dust Coated	Standard Coat	Shielded Arc.	Automatic Wire	Alloy Steel	Special Wires	Stainless Alloy	Totals
1/16	1.	50	50	50	145			54			349
	2.		425	425	366	650				276	2142
	3		310	600	820	12			26	1049	2817
3/32	1.	750	4460	5850	4225	300	352	465	830		17236
	2	1360	33072	9771	8686	30901	13570	78	379	6965	104922
	3.	623	9620	12650	12823	87494	9380	220	2293	17253	152356
1/8	1	2500	36930	40600	17860	13350	11508	6899	13053		202772
	2	35703	106571	85337	62867	170152	40371	3919	45207	7950	568077
	3	25233	107940	155610	73486	523184	41334	34928	24819	14282	1000816
5/32	1	17500	121260	128480	107165	24940	31424	23310	16241		112337
	2	30032	306622	223151	115919	774111	138883	27202	23002	10477	1649399
	3	27434	185805	383941	144712	1942230	255114	43161	44731	16878	2974006
3/16	1	2900	105570	60640	106100	105450	9675	38302	6255		443904
	2	65774	244357	171034	87780	1286423	32358	57178	32609	15835	1989348
	3	8963	149350	235633	94895	2398735	70676	64782	54052	16162	3093248
7/32	1	—	500	24400	14850	500		2000			43150
	2		500	1100	1500	117220	1155			535	122010
	3			250		135000	9994		22005		145244
1/4	1	4200	29500	30080	20400	75670	3281	10925	5875		179930
	2	7463	76257	52169	24062	700713	7640	25561	51126	1925	946916
	3		66001	70175	30197	1468483	31264	61633	950	709	1754066
5/16	1	1000	800	750	400	20590			409		22540
	2		4555	900	135	197016					204015
	3		1000	4550	2450	308780		1350			319080
9/32	1		2000		2400	2500			2900		2400
	2		3350								7400
	3							2150			5500
3/8	1	200	3050	400	250	4800					8700
	2		8867	450	162	33505					42984
	3		4900	1350	1000	69060		50			76000
1/2	1		1550			25					1575
	2		6500								6500
	3		2000								2000
Total.	1	27600	304200	300270	423800	295620	56240	84855	42254		1534883
	2	141272	789726	544337	297477	3313191	223977	113928	155832	43963	5633713
	3	65853	530275	794759	360383	6932978	417762	208274	148876	66333	9525493

Note. 1st set of figures June 1932

2nd " " " June 1935

3rd " " " June 1936

AUG 3 - 1936

with those of high grade steel castings. (B1).

✦ ✦ ✦

IT is significant that the steel producer sells wire to the electrode processer or manufacturer (shielded arc electrodes really are manufactured) on the basis of "Manufacturers Standard Specifications for Welding Wire (Filler Metal) in Coils, adopted January, 1934, revised June, 1934" that is essentially **on chemical analysis alone;** yet in selling his product the electrode manufacturer must meet the requirements of:

1. **Tentative Specifications for Filler Metal for use in Fusion Welding. American Welding Society, revised June 1, 1933.**
2. **Sections pertaining to Fusion welding of the A. S. M. E. Boiler Construction Code of 1932 and the Addenda of August 1934.**
3. **The 1934 A. P. I.-A. S. M. E. code for unfired Pressure Vessels for Petroleum Liquids & Gases.**
4. **Specifications No. 22W7c of July 21, 1934, for Welding Electrodes (bare, coated or covered) of the U. S. Navy.**
5. **Acceptance tests required by the American Bureau of Shipping for electrodes used on ocean-going vessels or lake or river craft within the territory of the U. S.**
6. **War Department U. S. Engineers specifications serial No. 1092-36-172F for arc welding electrodes.**
7. **Such tests and specifications prescribing bodies as numerous State Highway Departments, Building Code Committees of large Cities, Insurance Companies such as Hartford, Commercial Testing Laboratories, etc.**

all of which more or less erect definite minimum requirements of functional characteristics of the fusion metal produced with electrodes such as

Yield point
Ultimate tensile strength
Elongation under static load
Impact value
Specific gravity of the fusion metal

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THE chemical analysis of the electrode with which such fusion metal is produced influences but slightly the physical characteristics demanded, such variables as welding technique employed, skill of the operator, the welding characteristics of the machine, the influence of the admixed parent metal contribute a far greater and critical share to the final results.

THE LABORATORY
J. D. ADAMS MFG. COMPANY
INDIANAPOLIS, IND.

ARC-WELDING PROGRESS

April 30, 1934

Average Characteristics at 70° F.	Shielded Arc Fusion Metal	Bare or Lightcoated Wire Fusion Metal	Mild Rolled Steel
Ultimate Tensile Strength Lbs. Per Sq. In.	85,000-85,000	45,000-55,000	55,000-60,000
Yield Point, Lbs. Per Sq. Inch	50,000-55,000	28,000-32,000	34,000-35,000
Elongation, Percent in 2"	20-35	5-10	15-25
Reduction in Area, Percent	35-50	2-5	30-45
Impact Value, Charpy Ft-Lbs.	30-35	5-13	25-28
Impact Value, Izod Ft-Lbs.	45-60	8-15	40-65
Endurance Value, Ten Million Reversals Without Failure, Lbs. Per Sq. In.	28,000-30,000	12,000-15,000	26,000-28,000
Average Range of Locked up Residual Stresses (Grain Growth), Lbs. Per Sq. Inch in Area Adjacent to Fusion Zone.	3000-6000 Tens. Slag-Shielded 8,000-25,000 Tens. Gas-Shielded	10,000-35	Practically None

Figure 1.

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IT cannot be the purpose of this paper to give a condensed review of the physical, chemical and engineering application problems of the arc welding process, but since arc welding involves the melting of a low carbon steel electrode by the intense heat of the arc and the transfer of such metal across the same partly as metal vapor but mainly as a more or less regular stream of very small molten globules slightly below or right at the boiling point of whatever metal is involved, and furthermore since the entire metallurgical cycle, melting of the electrode, transfer across the arc gap, deposition on the work, congealing and final solidification in place and thereby joining whatever parts are welded, is consummated in a time interval from two to twenty seconds at the utmost, such physical or chemical phenomena which differ radically from those encountered in the usual steel mill practice should be described in detail in order to understand why the welding engineer has certain ideas regarding steel fabricated into electrodes.

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THE arc in arc welding is the means by which metal is transferred from the electrode unto the work, thereby creating the most perfect joint which mechanical ingenuity has devised so far. In order not to delve into the very intricate electrical phenomena which make this possible, the strikingly different manner of metal transfer when welding with bare electrodes or under shielded arc conditions is best illustrated by excerpts from a motion picture film made by **Jean Brillie** in 1931. At the left is shown the passage of a molten globule across the arc when using a bare electrode, at the right when using a heavily coated electrode of the same diameter, and chemical composition. Both experiments were photographed at equal rate of exposure, operator, machine and current setting were identical in both instances.

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WHEN welding with bare electrodes as shown by Figure 2, at 1 the globule is just forming at the tip of the electrode and at 2 it has already grown to a considerable size. At 3 the molten globule has formed a metallic bridge across the gap, short circuiting the welding machine, causing a drop in voltage to near zero and a considerable increase in current. In 3 is also illustrated the so-called "Pinch Effect" of **Professor Creedy** (B2) showing that through turbulence in the interior of a liquid conductor a narrowing or pinching effect takes place. At 4 the metal becomes superheated, gas and metal vapor is evolved which cause an eruption sidewise which finally in 5 produces the explosion of the liquid bridge across the gap and the re-ignition and re-establishment of the welding arc.

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THROUGHOUT all this time the globule of molten metal on the end of the electrode as well as the pool of molten fusion metal on the work, both superheated (close to the boiling point) are exposed to chemical action of the surrounding atmosphere.

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AT the right under shielded arc conditions at both 1 and 2 no globule of molten metal has as yet been formed; at 3 one is just beginning to grow at the end of the electrode; at 4 it has already left the electrode end and at 5 it is completing its flight across the gap and ready to be immersed into the pool of molten metal on the work. Throughout the entire elapsed time both globule and pool of molten

metal are enveloped by a dense mantle of neutral gases, completely shielded from the corrosive action of the atmosphere.

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THE oscillograph, a highly sensitive device which by means of mirrors actuated by the welding current records upon a fast moving photographic film simultaneously the instantaneous value of arc voltage, arc current and frequency of the supply current as a measure of elapsed time, is another means to visualize in full detail the manner in which metal is transferred across the welding arc.

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OSCILLOGRAPH Illustration No. 3 shows that when welding with bare electrodes (work as + pole or Anode, wire as—pole or Cathode) at fairly regular intervals through the growth of a large globule of molten metal at the tip of the electrode a metallic bridge is established across the arc which short circuits momentarily the arc welding machine, reducing the voltage to near zero and producing the characteristic short circuit current peaks. In one second 23 short circuits have taken place, that is 23 drops of molten metal have passed across the arc gap.

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OSCILLOGRAPH Illustration No. 4, same composition electrode, same operator, same welding machine, but now under shielded arc conditions (the electrode coated with a mixture of slag producing oxides of the alkali metals having a high thermionic emission effect, that is the ability to expel electrons at a relatively low temperature and organic substances disassociated through the heat of the arc into reducing gases such as CO and H_2 with an admixture of CO_2 and O_2 and used as the positive pole or Anode because in the D. C. arc from 70 to 75% of the heat energy is liberated on the positive pole) it is self-evident that distinct short circuits do no longer occur, the metal is transferred across the arc gap with a machine gun like rapid fire of very much smaller globules of molten metal. The arc voltage is higher because the constant stream of electrons emitted from the incandescent coating materials opposes or neutralizes to some extent the stream of negative electrons shot off from the incandescent cathode spot on the pool of molten fusion metal, thereby, increasing the apparent resistance of the arc gap.

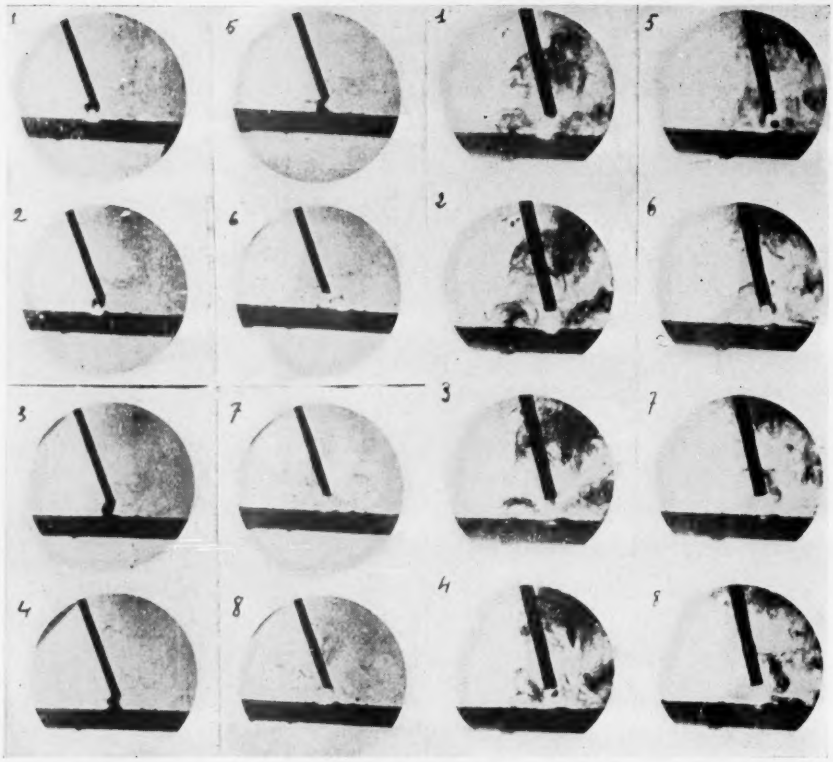

Figure 2. Chemical Action of the Atmosphere on the Electrode. ✦ ✦ ✦ ✦

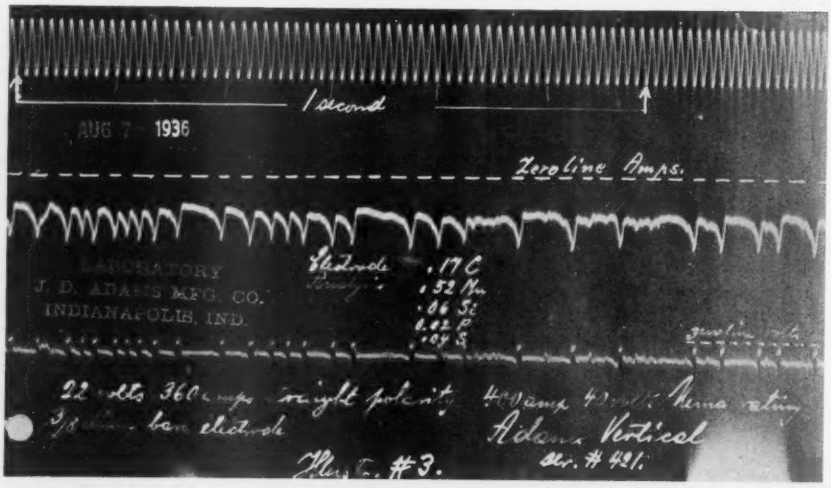

Figure 3. Oscillograph Illustration. ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

OSCILLOGRAPH Illustration No. 5 (same composition electrode, identical same coating as electrode in illustration No. 4, same operator, same welding machine) shows that when the "optimum current point" for a given electrode is exceeded, the additional amount of energy (watts) liberated in the arc as heat units does not produce an increased deposition rate commensurate with the additional energy expended, but that such

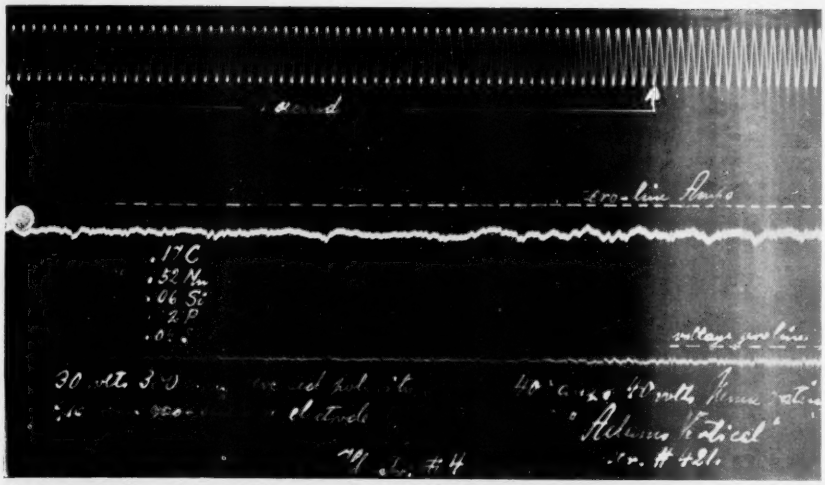

Figure 4. Oscillograph Illustration.

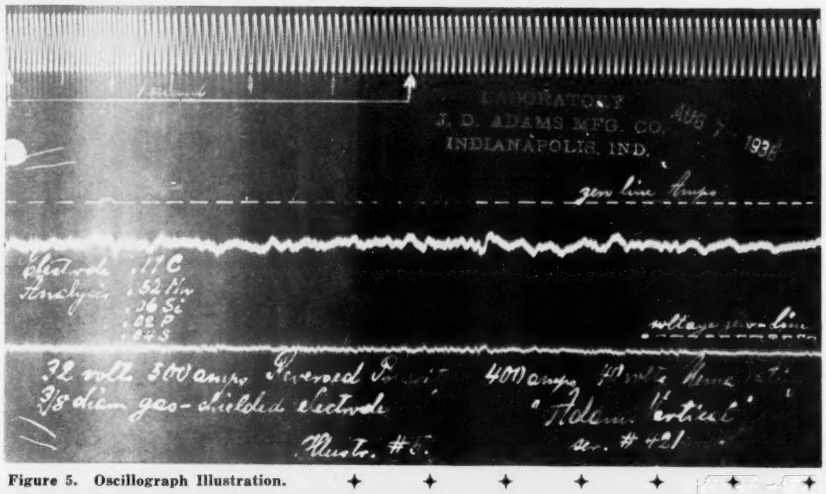

Figure 5. Oscillograph Illustration.

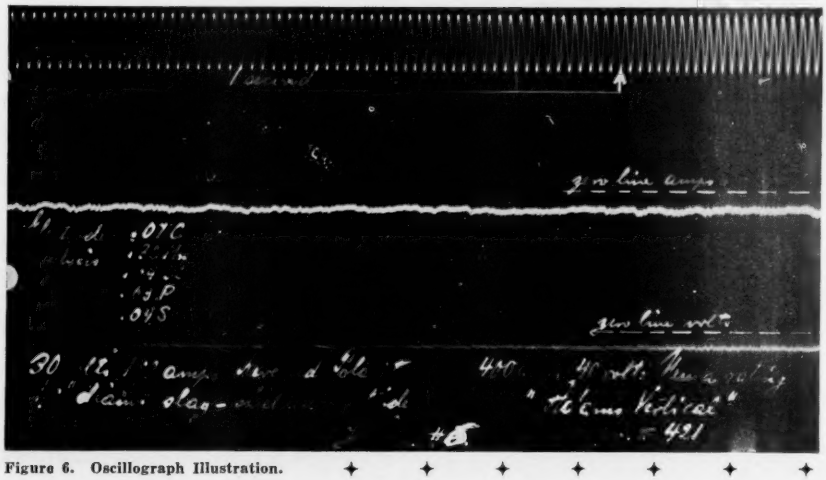

Figure 6. Oscillograph Illustration.

surplus is utilized to transform part of the liquid metal into metal vapor in which form it passes across the gap into the fusion metal. This very important phenomenon will be substantiated in the following through additional experiments and proofs.

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OSCILLOGRAPH Illustration No. 6 (welding with a low carbon 1/8" diameter slag-shielded electrode, reversed polarity, 30 volts, 180 amperes; a bare electrode would get red hot within a few seconds under these conditions) is an excellent example of the so-called "Chemical Stabilization of the Arc". This particular coating is extremely rich in ingredients of a high thermionic emission effect, thereby materially reducing the manipulative skill required from side of the operator to feed in the electrode at a uniform rate.

✦ ✦ ✦

IF the carbon content of the electrode is high (reducing both melting and boiling point) if as a minor contributing factor the wire is high in sulphur (mainly present as flake of manganese sulphide) but mainly when the steel contains an undue amount of monoxides such as FeO and MnO, then the very much feared gas explosions occur. This not so much during the actual transfer of the metal across the gap although the metal loss through spatter will be considerably increased, but mainly that in the large pool of superheated molten metal on the work through surface tension, gases and metal vapors collect into one large bubble which finally exploded and practically empties the pool on the work of fusion metal. This oscillograph Illustration No. 7 shows the tremendous disturbances of arc stability caused by the explosion-like liberation of gases from the tip of the electrode, further on will be shown at a tip of an electrode a crater-like depression over 3/32 of 1" deep caused by the disintegration of a flake of manganese sulphide.

✦ ✦ ✦

PROFESSOR G. E. Doan of Lehigh University with **Mr. J. M. Weed** (B3) developed an ingenious method which actually records all of the possible forms in which metal is transferred through the arc. The principal feature of the method involves the moving of a highly polished metallic strip under the arc at a speed sufficiently high to enable each successive deposit of metal to be made on the strip distinctly separated from the others. These experiments corroborate the fact that liquid glo-

bules are the chief form of metal transfer although some metal is transferred as vapor and mist. Some of the deposited drops plainly show cavities caused by the escape of dissolved gases before solidification took place. Since 5/32" diameter bare wire was used, most of the metal vapor was oxidized before deposition and appeared on the strip as a red powder of Fe_2O_3. A close correspondence can be seen between the individual types of deposit and the features of current and voltage waves on the corresponding oscillogram. It is especially noticeable that the size and duration of the current disturbance as recorded on the oscillograph film checks very closely with the size of the globule deposited on the moving mild steel strip. While these tests were made with bare wire, slightly different results should be obtained under shielded arc conditions, since a greater arc length and higher arc voltage would prevent the actual bridging of the arc gap by large globules of molten metal with the very pronounced current peaks and voltage zeros characteristic of bare wire welding. Citing verbatim from the article by **Professor Doan** and **Mr. M. Weed:** "Conditions involved in this test differ, of course, in some respects from those of ordinary welding. For instance, the heating of the strip under the rapidly advancing arc is insufficient to cause crater formation. Surface fusion does take place, however, beneath each globule, even at this speed, as examination shows the globules are tightly welded to the plate and resist removal by the chisel. Therefore, the temperature of the strip under the arc has been at least 1500° C. (the melting point of steel). A temperature considerable higher than this (probably 2450° C, the boiling point of iron?) exists at the crater in normal welding and, therefore, more heat is radiated from the crater to the wire tip, but the amount so radiated to the globule on the tip of the electrode, as calculated by the Stefan Boltzman law, seems to be less than 10%. This would not be sufficient to vaporize any considerable proportion of the globule before it left the wire and thus would not change appreciably the proportion deposited as globules."

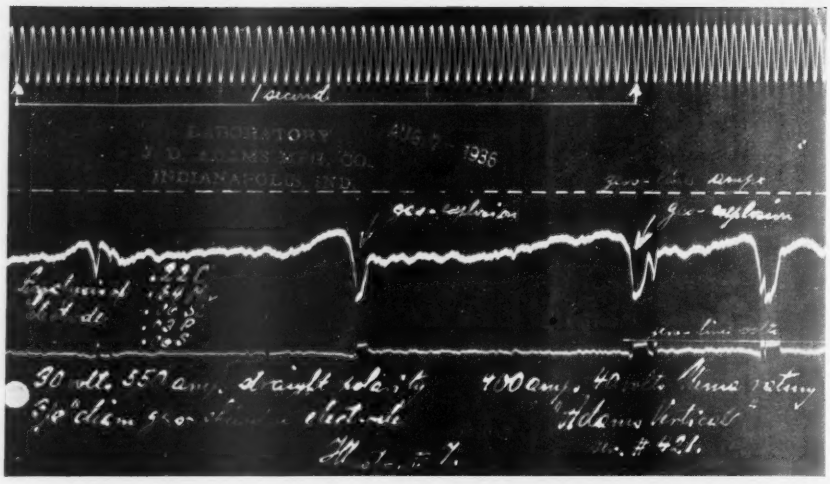

Figure 7. Oscillograph Illustration.

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THIS brings us to the problem of the temperature of liquid arc welding fusion metal. According to **Dr. H. Harris** (B4) the experimentally determined relationship between arc voltage V and arc length L can be expressed by the equation, $V = a + bL$, in which a and b are constants. The relation of the current c on the arc voltage is not governed by Ohms law, but conforms to the equation, $V = c + d/C^n$, where again c, d, and n are constants. These equations are not quite accurate when applied to welding arcs, as therein the metal transfer and the repetitive almost instantaneous short circuits caused thereby constantly change the relative value of the respective components of the above given equations. **Nottingham** by plotting "n" against the boiling point value of various Anode materials, discovered that a direct linear relationship existed.

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K. **K. Darrow** (B5) states: "These facts suggest that the arc tends so to adjust itself that its Anode boils; or else what seems a priori more plausible, that it generates heat so rapidly at the Anode that the electrode would speedily be raised to unheard of temperatures if it did not begin to boil and so arrest the rise. If this is right the factor determining 'n' may be the temperature of the Anode, not the fact of its boiling."

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THIS leads to the conclusion that a massive Anode which can conduct away the heat generated by the arc before a temperature approaching the boiling point can be reached, should reduce the value of the constant "n" below unity.

✦ ✦ ✦

THIS was verified by **Nottingham** who found for 1/4" diameter light-coated electrodes that "n" = approximately 0.5.

✦ ✦ ✦

CHECK tests in the laboratory of the **J. D. Adams Company** gave the following results for "n".

5/16" diameter .13-.18C light-coated 200 amp. 20 volts 'n' = .70
1/4" diameter .13-.18C light-coated 275 amp. 22 volts 'n' = .55
5/16" diameter .13-.18C shielded arc 225 amp. 32 volts 'n' = .85
1/4" diameter .13-.18C shielded arc 350 amp. 34 volts 'n' = .60

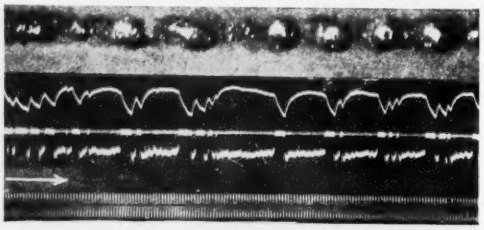

Figure 8. "Composite reproduction showing a section of the high speed metal record of actual deposition and the relation of the various deposits to the corresponding oscillogram". Courtesy of "Electrical Engineering". ✦ ✦ ✦

THE increase in the value of "n" in the instance of using shielded arc electrodes may be ascribed to the fact that refactory coating constitutes a crucible at the end of the electrode having a high thermal insulation effectiveness which prevents rapid dissipation of heat either through radiation or conduction into the unused part of the electrode.

✦ ✦ ✦

SEVERAL years ago the author (B6) attempted by means of a special compensated small observation point optical pyrometer to get direct readings of the temperature of arc welding fusion metal but had to concede that on account of the turbulence of the constantly changing radiant surface and the error introduced through the shielding slag the values obtained could be interpreted only as coarse approximations, although distinctly indicating that in metallic arc welding the Anode temperature under ordinary conditions will closely reach the boiling point of whatever metal is involved, the temperature of the Cathode will always be lower and can be modified only by the thermionic emission effect of the coating materials.

✦ ✦ ✦

NUMEROUS physicists have proven that the voltage drop across an arc in open air is not uniform, on the contrary, the maximum potential drop and, therefore, maximum heat liberation lies close to the very surface of both Anode and Cathode, whereas in the gaseous column of the arc core the resistance and, therefore, voltage drop remains fairly uniform and constitutes only a small part of the total, so consequently the temperature is materially lower in this area (B7) accounting for the fact that in the final dissipation of heat energy stored up in the congealing fusion metal, radiation plays the maximum, conduction the secondary, and convection only a very inferior part.

✦ ✦ ✦

IT is a generally accepted physical fact that the maintenance of an incandescent cathode spot is indispensable for the continued existence of any electric arc. It has been experimentally proven that the steeper the voltage drop or potential gradient in the gaseous layer next to the surface of the

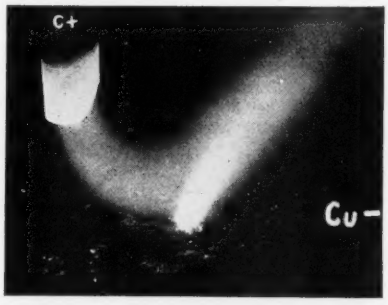

Figure 9. ✦ ✦ ✦ ✦

cathode, the smoother the welding arc and under such conditions maximum arc stability will be attained.

✦ ✦ ✦

THIS steep potential gradient at the cathode accelerates the velocity of the ejected electrons, thereby, increasing impact ionization; it also gives additional impetus to the positive ions (gas atoms with a positive charge emit-

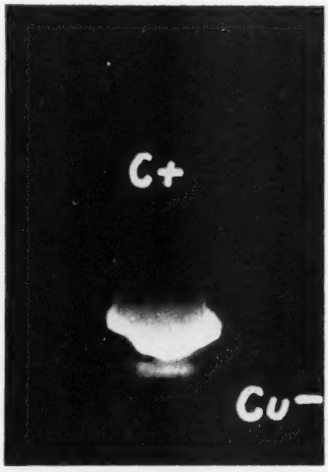

Figure 10. ✦ ✦ ✦ ✦

ted from the Anode) so that they in turn through their bombardment energy ($\frac{1}{2}$ mass x velocity^2) retain the cathode spot in its incandescent state.

✦ ✦ ✦

STEEL for arc welding electrodes in the old days of bare wire welding was used on the negative pole; today under shielded arc conditions the tip of the electrode is the Anode, therefore, the assertion that during welding with the mettallic arc the Anode temperature under ordinary conditions will closely reach the boiling point of whatever metal is involved, in itself explains the metallurgical difficulties experienced to degasify the super-heated fusion metal congealing in 5 to 15 seconds and the paramount importance of holding down in welding wire such gas producing monoxides as FeO x MnO.

✦ ✦ ✦

THE experiments of **Conrady** and **Mueller** (B6A) shown in the next four illustrations demonstrate to the metallurgist not versed in intricate electrical theories the principles involved in a visual almost self-explanatory manner.

✦ ✦ ✦

ILLUSTRATION No. 9 shows a carbon arc (used because steadier and therefore more easily photographed) played upon a pool of molten copper (on a large thick copper plate mounted upon asbestos board) which is in a state of continuous agitation through the rapid conduction of heat towards the solid metal. The carbon pencil is used as Anode, the incandescent cathode spot can be plainly seen on the pool of molten copper and the negative electron stream and the positive arc flame can be sharply distinguished.

✦ ✦ ✦

SINCE the arc sets up a slowly rotating magnetic field, the incandescent cathode spot slowly travels around the edges of this pool of molten copper and the negative arc flame is always distorted in an outward direction. From this it can be readily seen why so much arc blow and magnetic flare is encountered when welding with large diameter shielded arc electrodes at high current values under reversed polarity near the bottom of a large V butt-weld. Since such conditions create a considerable pool of liquid fusion metal, the essential cathode spot has the finest opportunity in the world to dance all over the surface of the liquid fusion metal.

✦ ✦ ✦

ILLUSTRATION No. 10 shows the maintenance of a carbon arc

under extremely disadvantageous conditions. The positive carbon has been immersed into a graphite crucible containing molten copper about ½" below the surface. The arc continues to burn because volatilization of the graphite of the carbon electrode (proving experimentally that the Anode tempera-

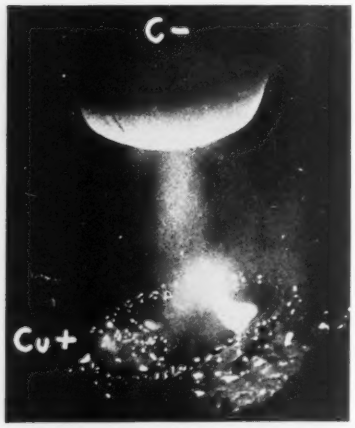

Figure 11.

ture must reach the boiling point of the material employed) is producing sufficient graphite or carbon vapor to create an envelope to isolate the incandescent carbon electrode with a layer of gas from the molten copper. If the positive carbon is now immersed still deeper so that the liquid negative copper can touch a black, that is cold surface of the carbon electrode, the arc is immediately extinguished through short circuit. If the polarity is reversed, that is carbon electrode as Cathode, molten copper as Anode, the experiment cannot be repeated for the obvious reason that the Anode temperature which equals the boiling point of copper is now so low that insufficient positive Ions are ejected from its surface and since the Cathode is now immersed into the molten copper, these few ejected Ions are distributed over a very large area and therefore, cannot bring the cathode or a spot thereon up to the boiling point so that the essential vapor or gas envelope is formed.

THE prevalent accepted arc theory assumes that the incandescent cathode spot ejects at very high velocity electrons, extremely small particles of electricity having but little mass action and that from the Anode atoms of gas with a positive electric charge, that is particles of tremendous greater mass action, are liberated and propelled towards the cathode. Illustration No. 11 shows at about 10 diameter magnification how this creates a suction in the liquid pool of copper acting as Anode, actually forming a small cone of molten copper which is supported through this drag of the positive Ions against the action of gravity and the opposing blow from the negative arc flame. This is just one example of what complicated forces are at play to enable us to arc weld overhead with reversed polarity using shielded arc electrodes of small diameter.

✦ ✦ ✦

A similar phenomenon is shown in illustration No. 12 magnified approximately 10 diameter between a carbon Anode and a molten pool of iron as cathode, that is under reversed polarity conditions. There is a pronounced depression on the surface of the liquid iron and contrary to gravity a cone of molten iron is growing towards the Anode which if the arc distance is maintained constant, will in the space of 2 to 3 minutes short circuit and extinguish the arc. This phenomenon cannot be demonstrated under otherwise identical conditions with straight polarity, nor under reversed polarity with an iron electrode playing upon a carbon plate.

✦ ✦ ✦

JUST as certain metallic oxides especially those of the alkali metals through a higher thermionic emission effect will substantially increase the negative arc flame, other substances especially incandescent carbon particles, can

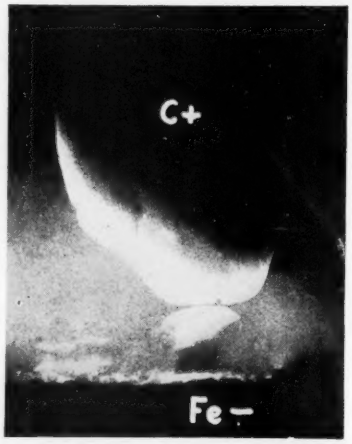

Figure 12.

materially reduce the same through an opposing stream of Ions flowing from the Anode towards the cathode. If a wire say of .90 carbon is used on straight polarity, the arc is extremely wild and erratic, large globules of metal seem to reluctantly hang on the electrode tip and freeze immediately upon transfer, no penetration is obtained in the parent metal and there is a tendency to form areas of incomplete fusion. Using reversed polarity, conditions are materially improved, although now considerable less current will have to be employed. It, therefore, must be assumed that electrodes of higher carbon content than .20% when used on straight polarity eject from the molten pool of fusion metal a sufficient greater amount of positive Ions, mainly carbon monoxide but also some very small incandescent carbon particles to materially reduce the negative arc blow. That small incandescent carbon particles, carbon in vapor form and incandescent carbon

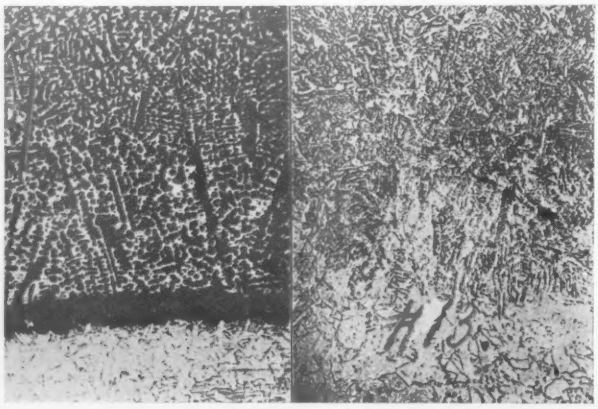

Figure 13.

monoxide atoms exercise a directional proference in an electro static field, that is exhibit a tendency to wander from the positive towards the negative pole can be best demonstrated through the example of the D. C. carbon arc lamp, where the positive carbon always burns twice as fast as the negative and where incandescent carbon particles and carbon vapor are actually transferred across the arc and gradually increase the size of the negative carbon.

✦ ✦ ✦

THE fact of this directional preference of incandescent carbon particles or carbon vapor in an electro static field (the main contributory factor which enables us to deposit fusion metal overhead with small diameter shielded arc electrodes under reversed polarity) can be proven by an experiment of intense practical value. Illustration No. 13 shows at the left at 100 diameter magnification the structure near the surface of a .35-.45 carbon plate molten through the application of a ¼" diameter carbon electrode using about 175 amperes reversed polarity or the carbon as Anode. The surface has been carburized to an almost unbelievable degree, a chemical analysis showed a carbon content from 2.5 to 2.8%. On the right is shown the structure of the same medium steel plate, the surface of which had been molten under identical conditions except that now straight polarity had been used, that is the carbon electrode as negative pole or Cathode. Here a very little carbon pick up is shown, the chemical analysis revealed a carbon content of .58 to .62%. Most remarkable is the difference in the transition zone between metal recrystallized through fusion and original parent metal. At the left where reversed polarity was used for the liquification of the surface, there is even a layer of extremely high carbon content whereas in the second instance under straight polarity the transition is very gradual.

✦ ✦ ✦

OVERHEAD welding with a 5/32" diameter .05C .16 Mn

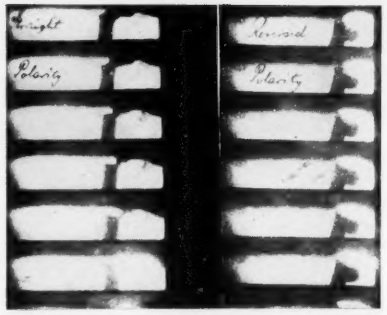

Figure 14. ✦ ✦ ✦ ✦

light-coated electrode, 95 amperes, 18 volts, left straight, right reversed polarity.

✦ ✦ ✦

ALL these phenomena discussed in the foregoing explain why it is so much more easier to do overhead welding with a .04 to .06% carbon about .15% manganese electrode using straight polarity than when using a .13-.18 carbon .40-.60 manganese electrode same diameter, same current flowing but employing reversed polarity.

✦ ✦ ✦

IN the first instance, the melting point is higher, causing a quicker freezing of the fusion metal which is essential as you cannot

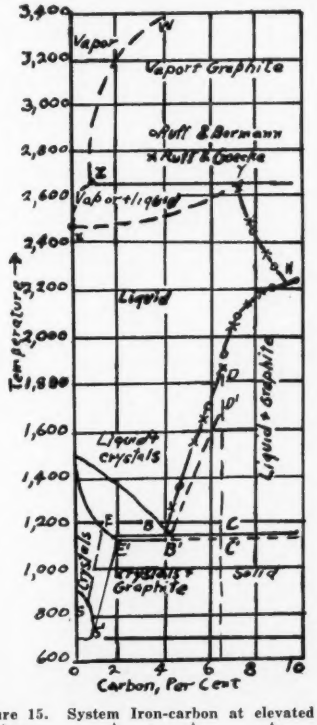

Figure 15. System Iron-carbon at elevated temperatures. ✦ ✦ ✦ ✦

maintain a large pool of fusion metal overhead. The surface tension of the molten metal is lower which permits the forces of cohesion to offset to a large extent the opposing gravitational pull. And last but not least, the negative arc stream is larger assisting the transfer of the metal.

✦ ✦ ✦

THE case presented so far indicates by experimental evidence that

a. **While metallic globules are mainly the means by which metal is transferred across the arc, nevertheless there is always some incandescent metal vapor which under disadvantageous condition or excessive current flow may reach a value of better than 50% of the total amount of electrode material molten in the arc.**

b. **If the electrode is used as Anode, fusion metal temperature will always be close to the boiling point of whatever metal is involved; under straight polarity conditions especially with heavy current flow the temperature of the pool of molten metal on the work will be only slightly under the same value.**

✦ ✦ ✦

THEREFORE, in arc welding metallurgically we are dealing with a low carbon content iron alloy highly saturated with metal vapors and gases and are mainly interested to hold down to the irreducible minimum such ingredients and reactions which may liberate additional gas especially during the few seconds available for congealing.

✦ ✦ ✦

FROM German sources **Lidell & Doan** (B8) compiled the iron-carbon equilibrium diagram at elevated temperatures as shown in illustration No. 15. This is of special importance to the Welding Engineer as it gives definite information of the range between 2450° and 2680° C. where the liquid iron carbon alloy becomes super-saturated with metal vapor without actually boiling whereas above the Z-Y range only a definite vapor phase can exist.

✦ ✦ ✦

SINCE arc welding fusion metal is always close to its own boiling point and since part of the electrode is transferred across the arc gap in vapor form, there is not only a considerable volatilization

loss of essential strength and ductility giving alloy ingredients, but also there is a contamination through oxygen and nitrogen, since iron carbon alloys readily react with both gases at elevated temperatures.

✦ ✦ ✦

THE tabulation given here of the percentage volatilization loss of essential alloying ingredients (manganese and carbon) and the considerable pick-up of oxygen and nitrogen when welding with bare electrodes by no means covers all the available data on the subject but rather brings out that coating the electrodes has been effective not only in reducing the contamination of the weld metal but through skillful additions of, for example Ferro-Manganese or Ferro-Silicon or Ferro-Titanium, to the coating materials compensates for the loss of managanese which has a considerable lower boiling point (1900° C) than mild steel (2450-2500° C).

✦ ✦ ✦

METALLURGICALLY the quick freezing arc welding fusion metal represents as compared with a steel casting an accelerated condition as far as the tendency to form gas voids or blow holes is concerned. Areas of incomplete fusion in most instances are solely due to lack of manipulative skill from side of the operator, slag inclusions or gas bubbles are mainly created by improper metallurgical reactions.

✦ ✦ ✦

SINCE voids within the structure of the fusion metal impairs mainly through notch effects and mechanical stress concentrations, the kinetic properties such as fatigue resistance and impact value the A. P. I. and the A. S. M. E. codes for example insist upon both a specific gravity and radiographic tests to weed out welds suffering from porosity. While it cannot be the purpose of this paper to go into the chemistry and the metallurgical effects of electrode coatings, nevertheless the measures taken, de-oxidation through the covering slag, de-oxidation and de-gasification through ferro-silicon, ferro-titanium, ferro-manganese or the reducing influence of CO and H_2 shielding gases developed from carbo-hydrate coating materials (paper, cotton, wood flour, cellulose-acetate, starch, dextrin, etc.) by necessity must influence the physical characteristics of the resulting fusion metal.

✦ ✦ ✦

SLAG shielded electrodes whose coatings consist to a large part of such materials as asbestos, feldspar, mica, steatite, titanium dioxide, calcium carbonate, magnesium carbonate, the various aluminas such as bauxite, fluorspar, or calcium flourite, the natural ores of manganese, titanium or iron held together by a suitable binder such as dextrin, various gum and resin, cumarone but mainly silicate of soda, form a blanket of slag over the congealing fusion metal.

✦ ✦ ✦

THIS not only retards congealing thereby permitting entrapped slag particles or gas bubbles to rise to the surface, but also permits considerable equalization of contraction stresses of the parent metal through creep. The most important function of such slag is its chemical reaction upon the fusion metal.

✦ ✦ ✦

THE slag forming constituents of an electrode coating must, therefore, perform the following functions.

1. **Liberate electrons at a relatively low temperature, that is ionize the arc gap long before the tip of the electrode begins to melt.**
2. **Have a melting point close to that of the electrode material so that coating and electrode melt at approximately the same rate.**
3. **The molten slag must have a low**

Illustration #16

VOLATILIZATION LOSS OF C & Mn AND O & N PICK UP IN FUSION METAL

Reference	Type of Coating	Electrode					Fusion Metal							Physical Properties of Fusion Metal			
		C	Mn	Si	P	S	C	Mn	Si	P	S	O	N	Yield Point	Ultimate Tensile	% of Elongation in 2"	Spec. Gravity
B 9		.07	.37	.013	commercial steel samples							.043	.008				
B 9		.13	.72	.02	commercial steel samples							.020	.012				
B 10	Slag Shielded	.13 .16	.40 .60	.08	.04	.04	.10	.36	.10	.019	.020		.05				
B 10	Gas Shielded	.13 .16	.40 .60	.08	.04	.04	.075	.50	.15	.019	.034		.019				
B 11	Slag Shielded	.073	.43	.04	.025	.037	.04	.25	.015	.019	.028	.021	.02	45000	65000	35	7.3
B 11	Bare	.073	.43	.04	.025	.037	.01	.03	.005	.019	.035	.29	.15	32000	51000	6	7.1
B 11	Gas Shielded	.145	.47	.02	.03	.035	.07	.35	.015	.028	.03	.05	.03	55000	72000	28	7.35
B 11	Bare	.145	.47	.02	.03	.035	.03	.075	.01	.029	.032	.32	.14	31000	49000	5	7.05
B 11	Gas Shielded	.12	.45	.02	.02	.035	.08	.38	.01	.018	.032	.06	.03	56000	74000	27	7.3
B 11	Gas Shielded	.11	.40	.02	.02	.035	.07	.32	.01	.018	.031	.05	.03	64000	82000	24	7.35
B 12	Bare	.08	.47	trace	.013	.03	.01	--	.01	.01	.031	.237	.162		48000	3.1	
B 12	Gas Shielded	.05	.46	.02	.010	.02	.04	.67	.03	.01	.039	.114	.021		68000	34	

surface tension to readily spread over the entire surface of the pool of molten metal on the work as otherwise it cannot protect the liquid fusion metal against contamination by oxygen or nitrogen of the surrounding atmosphere.

4. **By influencing the apparent resistance of the arc gap the coating ingredients through their specific thermionic emission effect should permit a regulation of the deposition rate, that is an increase or decrease of melting efficiency expressed as watt minutes per gram of electrode material melted down.**
5. **Regulate within narrow limits the freezing or congealing of the fusion metal.**
6. **Regulate the rate of cooling of the congealed fusion metal.**
7. **Last but not least, refine and degasify through chemical reaction the liquid fusion metal.**

✦ ✦ ✦

ARC stability is mainly influenced by the relative number of Ions and electrons present in the arc stream at any given moment, also by the presence or absence of certain gases. The amount of heat liberated in a welding arc with a definite current flowing is directly proportional to the voltage drop across such an arc But this consists of three components, the anode drop and the cathode drop (the two regions where the maximum amount of heat units are liberated) and voltage drop of the arc stream proper (the gaseous flexible conductor) which is much less than either anode and cathode drop, and which varies only at a uniform increment rate with the arc length employed. The thermionic emission effect of coating materials practically determines not only arc voltage, but also whether a given coating combination is best used on straight or reversed polarity or even suitable for A. C. welding.

✦ ✦ ✦

SINCE for all practical purposes the chemical composition of the electrode steel is near enough identical, it therefore requires a definite number of heat units to melt a definite weight of electrode steel. But it also takes a certain amount of heat units to melt the slag or gas forming coating ingredients and this explains the difference in deposition efficiency of various types of shielded arc electrodes.

✦ ✦ ✦

DEPOSITION or melting efficiency should be expressed as watt minutes per gram of electrode material molten down, the electrical energy of the arc available for heat liberation, that is melting effect is the product of anode and cathode voltage drop times welding current flowing, the voltage drop across the arc stream does not liberate enough energy to effect the melting rate). It is possible, however, to increase deposition efficiency by incorporating into the coating material certain metals in finely divided form capable of an exothermic reaction with the metallic oxides of the coating.

✦ ✦ ✦

SEE U. S. Patent No. 1,905,648 issued April 25, 1933. Claim 5: **"A coating composition for an arc welding rod, comprising a mixture of approximately one to two parts of ferric oxide, one part silica, a binder, and a finely divided metal capable of reducing iron oxide at the temperature of the arc. The chemical reaction taking place = 2 Fe_2O_3 + 3 Si = 4 Fe + 3 SiO_2."**

✦ ✦ ✦

WHILE in the last two years some attempts have been made to manufacture electrodes from killed steel, this so far has not been very successful. Practically 95% of the .13-.18 carbon electrode steel used today is made from rimmed ingots, containing approximately .02% silicon. A neutral slag will not effect fusion metal melted down from such steel whereas a basic slag will slightly reduce the oxygen and silicon content. A slag high in FeO, that is highly oxidizing, will lower not only the silicon, but also the manganese content and the resulting fusion metal will freeze quickly. (Several shielded arc rods capable of welding vertical and overhead in the 1/8, 5/32, and 3/16 inch diameter size all produce an oxidizing slag.)

✦ ✦ ✦

AS practically 95% of the gas-shielded electrodes sold in the U. S. today are copies or slight improvements upon U. S. patent No. 1,301,331 issued to **R. S. Smith** and U. S. patent No. 1,754,063 issued to **R. Stresau,** it might be of interest to the reader to cite verbatim from the brief of the Plaintiff Appelant (U. S. Circuit Court of Appeals, Sixth Circuit No. 6863, A. O. Smith Corporation Plaintiff Appelant vs. Lincoln Electric Company, Defendant Appellee, In Equity No. 3515) regarding the operation of the typical gas-shielded weld-rod:

"The elements which are essential to the operation of both the Smith and Stresau weld-rods are a substance which decomposes into reducing gases that protect the weld metal and another substance which preserves the first from premature decomposition. The sodium silicate used to control the decomposition of the cellulosic material is chemically the same in the Smith and Stresau coverings. The same advantages that are derived by Smith from the use of cellulosic material that acts as a chemical package to hold large volume of reducing gas in the weld-rod covering, are also obtained by Stresau by the use of the same chemical package in an improved physical form which not only permits of its more ready and economical application to the weld-rod, but insures a more uniform and satisfactory performance of its function. In general the Smith and Stresau coverings function in a similar manner because of the similarity in chemical composition. In both coverings the cellulosic materials decompose to produce reducing gases that form a gaseous shield about the weld metal and protect it from the deleterious elements in the atmosphere; the sodium silicate protects the cellulose from combustion with the air and preserves it for decomposition into reducing gases; the combination of cellulose with sodium silicate results in the formation of a crater which directs the gas into the arc space; and silicon is reduced from the silicates in the covering to produce free silicon which alloys with the weld metal where it insures the absence of iron oxide. Like the Smith weld-rod, the Stresau weld-rod and defendants Fleetweld weld-rods, operate at a high arc voltage, have the same greater proportional heating effect with the attendant advantages of better penetration and fusion of the parts to be welded and are capable of use for high speed welding."

✦ ✦ ✦

IN the Reply Brief, for Plaintiff Appellant, United States Circuit Court of Appeals, Sixth Circuit No. 6863, the analyses of the coatings are given in table A.

✦ ✦ ✦

IF the slag producing constituents are summed up in each instance it will be seen that the slag forming materials make up 40.44% of the Smith covering, 53.65% of the Stresau covering, 59.40% of Fleetweld (old) and 56.43% of Fleetweld (new).

✦ ✦ ✦

WITH reference to coatings which produce mainly FeO (MnO) SiO_2 slag they are mainly manufactured from the natural ores, the metallurgical reactions

during arc welding are approximately as follows:

The FeO x MnO react with the silicate of soda or the quartz sand of the coating and form complicated silicates as per equation.

$3\ SiO_2 + 2\ FeO = (FeO)_2\ (SiO_2)_3$. Through an excess of FeO a monosilicate is formed as follows:

$(FeO)_2\ (SiO_2)_3 + FeO = 3(FeO — Sio_2)$

✦ ✦ ✦

SINCE the free FeO of the slag combines with the silicates, the slag is able to absorb FeO from the liquid fusion metal, because the work of **C. H. Herty, C. F. Christopher & H. Freemann** (B13) and **F. Korber & W. Oelsen** (B14) has pretty nearly definitely proven that with good contact at sufficient high temperature

FeO — slag = constant
FeO — fusion metal

✦ ✦ ✦

IN other words, the coating composition must contain sufficient silicate of soda to enable combination of the total free FeO x MnO of both slag and fusion metal into the respective Fe-Mn silicates.

✦ ✦ ✦

WHILE this requires that the equilibrium demanded by the law of mass action must be attained within the very short time of 5 to 20 seconds, actual experience proves sufficient response of the fusion metal composition in accordance with the above to any modification of the oxides or metals in the slag; probably due to the fact that the violently agitated molten metal is brought into intimate contact with the slag at temperatures still close to the boiling point of both.

TABLE A

		R. S. Smith	Stresau	Fleetweld (old)	Fleetweld (new)
Silicon Dioxide	SiO_2	30.07	38.95	31.67	31.11
Aluminum Oxide	Al_2O_3	4.09	6.56	2.80	.25
Calcium Oxide	CaO	.028	.035	.056	.042
Magnesium Oxide	MgO	.13	.47	7.74	6.92
Sodium Oxide	Na_2O	6.12	7.63	7.237	7.45
Potassium Oxide	K_2O	trace	0	0	trace
Titanium Oxide	TiO_2	.....	.....	9.89	10.57
Iron	Fe	.21	2.20	2.42	2.6
Manganese	Mn	.12	8.93	3.57	10.33
Carbon	C	21.68	11.458	9.697	10.73
Carbon Dioxide	CO_2	.47	.71	.645	.95
Hydrogen	H_2	3.383	1.98	1.799	1.818
Oxygen	O_2	27.067	13.07	14.392	14.542
Water, free	H_2O	6.7	8.01	7.53	2.37
Total %		100.068	100.003	99.446	99.682

ON gas-shielded electrodes, since the expulsion of entrapped gas-bubbles and slag particles depends to quite some extent upon the viscosity or better the fluidity of the covering slag, and since this in turn is affected by the $CaO\text{-}SiO_2$ ratio, it is almost essential that the coating composition contains better than 25% SiO_2.

✦ ✦ ✦

EXPERIENCE has shown that metal admixtures to welding rod coatings capable of an exothermic reaction under the arc that is a degasifying or de-oxidizing influence are confined to carbon, manganese, silicon, aluminum, and titanium. The British manufacturers especially prefer the addition of a very small diameter pure aluminum wire spiraled around the electrode proper and covered by the coating. In the U. S. shielded arc electrodes have been marketed containing a certain amount of pulverized ferro or ferro-titanium-aluminum, without making much headway against the very successful admixture of a small amount of ferro-silicon or ferro-manganese or a combination of both. The following facts might also be of interest.

✦ ✦ ✦

CO as well as the oxides of most of the alkalies reduce the melting point of the usual slag forming ingredients, the oxide with the lowest molecular weight using equimolecular weight of substance shows the greatest reduction.

✦ ✦ ✦

FLUIDITY and melting point of slag is determined by its

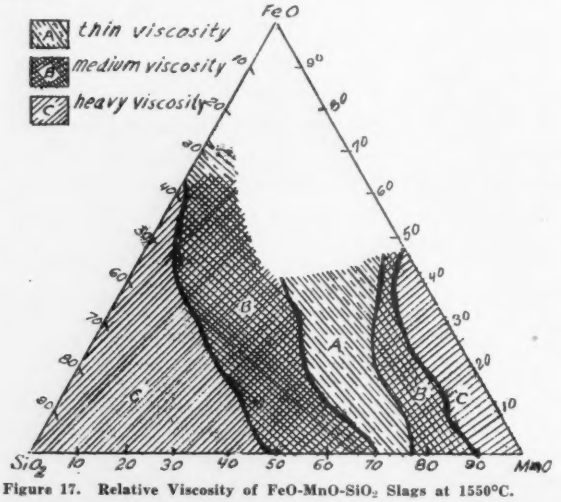

Figure 17. Relative Viscosity of FeO-MnO-SiO_2 Slags at 1550°C. ✦

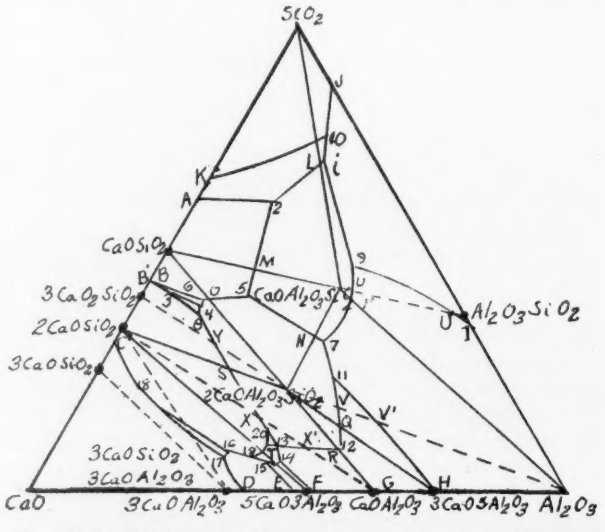

Figure 17A. Diagram of the ternary system, showing the various binary systems within ternary system of Calcium, Silicon, Aluminum Slag. ✦

relation between basis fluxes against aluminas and silicas.

$$Al_2O_3 + SiO_2$$
$$Fe_2O_3 + CO + MgO — MnO$$

✦ ✦ ✦

IN an oxidizing arc flame Fe_2O_3 does not attack or combine with silica, under reducing conditions it readily forms iron-silicates, which act as a solvent upon the more refractory alumina.

✦ ✦ ✦

CARBON monoxide in the electric arc is disassociated into carbon and carbon dioxide, $2CO = C + CO_2$, this depends upon the presence of Fe_2O_3 which acts as a catalyzer. (Does not take place below 900° C.)

✦ ✦ ✦

SILICA and iron oxide form Fe_2SiO_4, this more readily if a small amount of MgO is present.

✦ ✦ ✦

INCREASING the Al_2O_3 content increases the viscosity of the slag. Iron oxide always acts as a basic slag producer, but CaO is still more basic and its silicates most readily combine with FeO.

✦ ✦ ✦

TITANIUM and magnesium oxides also act as basic fluxes upon silicas.

✦ ✦ ✦

USING electrodes or welding on parent metal high in phosphorus a de-phosphorizing action is produced only with a coating high in Fe_2O_3 and low in SiO_2. If the SiO_2 content is higher than the total content of basic materials, phosphor is returned into the fusion metal.

✦ ✦ ✦

REGARDING the very slight desulphurizing action of the manganese content, for best results it should not exceed 0.7% in the electrode material proper. Should be present in the coatings as a carbonate when the other ingredients exercise a reducing action or preferably as MnO_2 so that in the slag beside the MnS also sufficient MnO is present to combine free SiO_2 to $MnSiO_3$ as otherwise the surplus SiO_2 causes a reduction as follows:

$MnS + FeSiO_3 = MnSiO_3 + FeS$, the formed FeS is readily re-absorbed by the fusion metal.

✦ ✦ ✦

THE combustion of carbon within the liquid superheated fusion metal results in forming CO. This reaction is more intense when the Si and Mn content is low. It increases also with the temperature.

$$FeO + C = Fe + CO$$
$$Fe_3C = 3\ Fe + C$$
$$FeO + Fe_3C = 4\ Fe + CO$$

✦ ✦ ✦

EQUILIBRIUM at constant temperature = PCO (FeO) (Fe_3C) where PCO is the pressure of the confined CO.

✦ ✦ ✦

THE silicon reaction is $2\ FeO + FeSi = 3\ Fe + SiO_2$. This is reversible, therefore, the silicon equilibrium condition is $E = (FeO)^2\ (FeSi)\ (SiO_2)$.

✦ ✦ ✦

PROPER manganese content is vital for reducing the FeO content. The reaction is $FeO + Mn = Fe + MnO$ + 32 calories.

✦ ✦ ✦

THE equilibrium is E= (FeO) (Mn) (MnO).

✦ ✦ ✦

WHEN using bare or light coated electrodes, that is welding with no or insufficient shielding, the following reactions may take place

$$6\ FeO + O_2 = 2(FeO — Fe_2O_3)$$
also $$Fe_3O_4 + Fe = 4\ FeO$$

FROM the above follows, as has been amply proven in actual practice, that through suitable additions of ferro-manganese, ferro-silicon and carbonaceous substance to the coating materials the volatilization loss of carbon and manganese cannot only be materially reduced, but it is possible to obtain within certain limit of a definite C and Mn content of the fusion metal, furthermore that a coating composition designed upon a CaO (SiO_2) slag basis permits a certain regulation of the Fe-Mn ratio of the fusion metal.

✦ ✦ ✦

THE steel industry has no difficulties to hold both the sulphur and phosphor content in electrode steel below the specified .04% (only the U. S. Navy demands for class EA. heavy coated shielded arc type electrodes .030P— & .035S maximum and the same for class EB. bare and light coated) and this corresponds well to good steel casting practice. **Bull** in a Symposium on Steel Castings (American Foundrymen's Association and A. S. T. M. Joint Meeting, Atlantic City, June 21, 1932) holds that

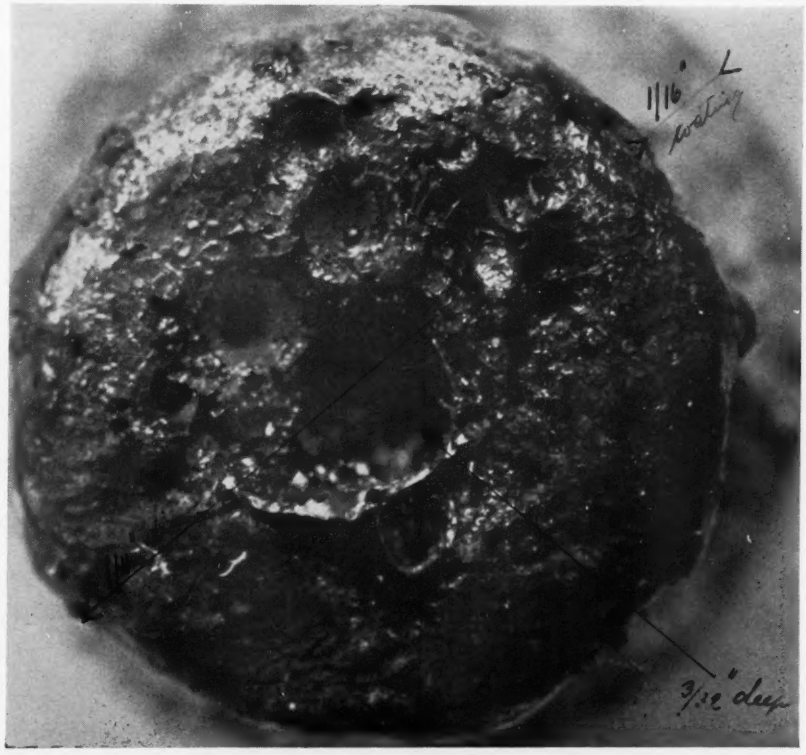

Figure 18.

✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

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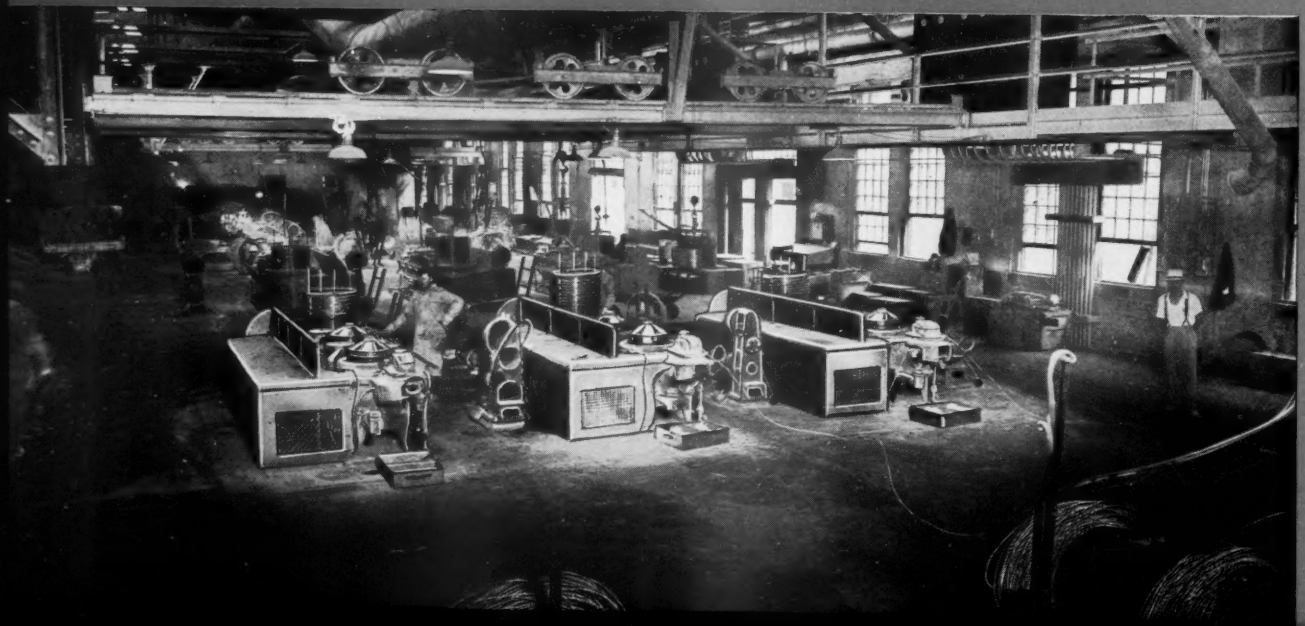

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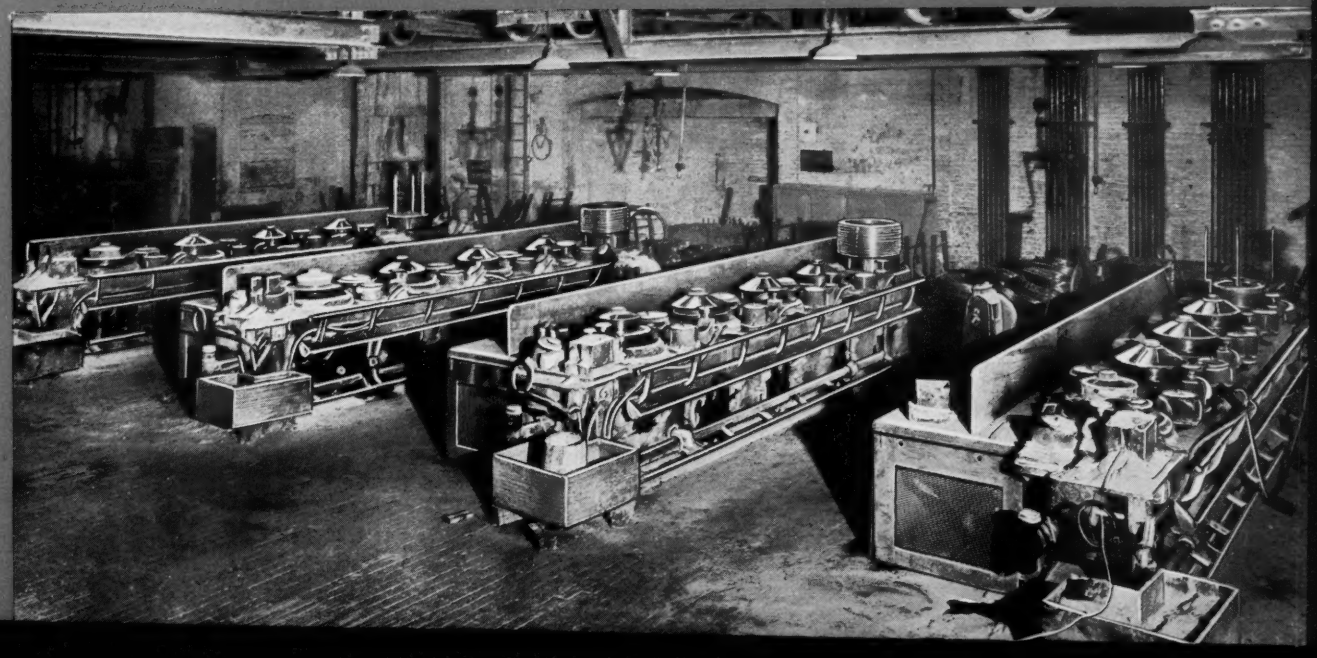

there is no tendency to disagree on the limit of .05% for phosphor in steel mastings to safeguard against cold shortness. Regarding sulphur (beside FeO the main cause for red-shortness in fusion metal) 2 standard A. S. T. M. specifications for steel casting call for a maximum of .06%, the other and most important one sets the limit at .05%.

✦ ✦ ✦

THE work of many careful investigators in the past 5 years confirms the assertion that manganese sulphide flakes or a pipe of Fe_3O_4 elongated into a fibre or stringer through the wire drawing process is the most prolific source of the much feared gas explosions and high spatter losses in a mild steel electrode. (Such manganese sulphide flakes or inclusions explode at arc temperatures forming SO_3 gas.)

✦ ✦ ✦

ILLUSTRATION No. 18 shows the explosion crater of a manganese sulphuric flake (crater is actually 3/32″ deep) on a 1/4″ diameter .16 C .52 Mn gas shielded electrode. This came from a lot showing excessively high spatter losses and chemical analysis of the unburned end of this electrode revealed a sulphur content of .07% and an oxygen content of .11%.

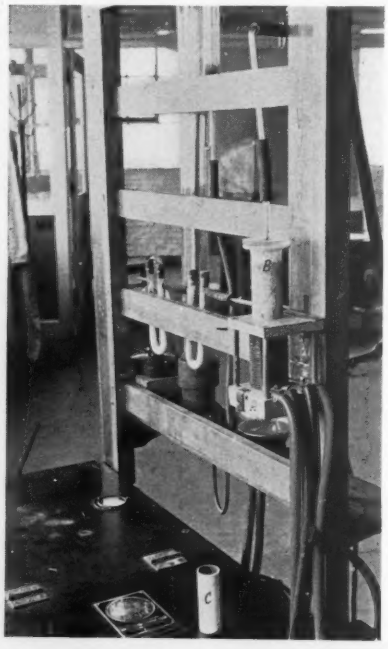

Figure 19. ✦ ✦ ✦ ✦

While of course occasionally oxides of Al, Ti, Si, Mn, V, Zr, Co, and Mg (residue from ores or the deoxidation process) are encountered as inclusions in the electrode material which may at arc temperatures cause gas liberation, they are so rare as not to be of practical importance. The trouble makers are in the descending order of their effectiveness.

1. **The sulphides of Mn and Fe**
2. **The oxides of Mn, Fe, Si, and Al**
3. **The silicates of Fe and Mn**

✦ ✦ ✦

STEEL drawn out into wire for arc welding electrodes must not only have a minimum content of dissolved gas but more important must be reasonably free of non-metallic inclusions (oxides and microscopic slag particles) which through chemical reaction at elevated temperature form gas which is suddenly released at the moment of congealing causing porosity in the fusion metal. The criterion is the solubility of such oxide and slag inclusions in the metal, if they are of only microscopic proportions, insoluble and fairly uniformly distributed throughout the structure of the metal, the detrimental effect won't be very serious neither as far as reduction of physical characteristics nor gas evolution is concerned. The deoxidation process by means of ferro-manganese or ferro-silicon is nothing but a rather successful attempt to change soluble monoxides into insoluble ones which being very much lighter than the metal involved have a better chance of being eliminated by rising to the surface and becoming part of the slag.

✦ ✦ ✦

THE vacuum fusion method is the most practical one now available to determine the total amount of gas or gas forming ingredients present in a metal. (See reference B15, 16, 17 and 18).

✦ ✦ ✦

WHILE it gives only the total amount of both the dissolved and the reactively liberated gas (the various oxides in the metal will react with either the alundum or graphite crucible employed) nevertheless we remelt electrode steel under very similar conditions in arc welding instead of a reduced pressure we employ greatly elevated temperatures and a covering slag which is capable of causing gas liberation. It can be safely stated that no metal manufactured under commercial melting conditions can possibly have reached a state of actual equilibrium and even if this should happen through some particular fortunate combination of chemical composition and temperature, this would be terminated as soon as such metal begins to solidify. (Mild Steel electrode material contains from .04 to .19 carbon plus from .03 to .08 oxygen, if equilibrium had been accomplished, the oxygen should have been completely eliminated with a corresponding reduction of the carbon content).

✦ ✦ ✦

IN order to have a measuring stick as to how much gas various electrodes would develop, we built, based on designs of Jordan and Vacher and L. Reeves but very much simplified, the Vacuum Fusion Gas Determination Apparatus shown in illustrations No. 19 and No. 20. This consists essentially of a 3 Kva Ajax Northup High Frequency Converter energizing the water-cooled helix of the High Frequency furnace A. The specimen (about 25 grams) in the Alundum or Graphite Crucible C is inserted into the quartz tube B, through the high vacuum pump D

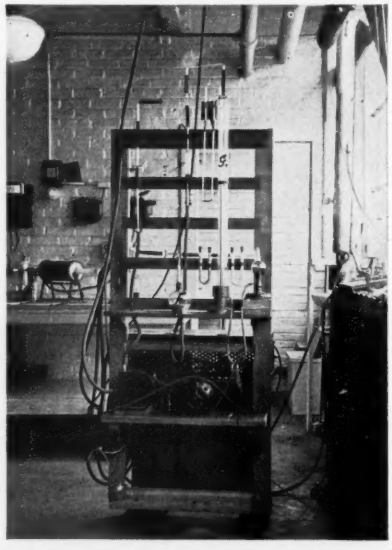

Figure 20. ✦ ✦ ✦ ✦

the quartz tube is exhausted to 1½ to 2 mm pressure. Through induction from the high frequency current (10,000 volts at approximately 800,000 cycles) the specimen is molten in about 2 to 6 minutes and as the gas is developed, it is pumped into the collection chamber E by the mercury pump F. If after 15 to 20 minutes no more gas can be pumped over, it is safe to assume that the reactions are completed, although for the check purpose a capillary manometer could be installed into the system.

✦ ✦ ✦

THROUGH a suitable arrangement of stop-cocks and connections, the gas collected in E can be pumped over into the measuring burette G, reduced to atmospheric pressure and measured in cubic centimeters. No attempt is made by us to analyze the evolved gas and split it into its components as this has been previously done in a conclusive manner by the references cited. From a welding engineering viewpoint, we are but little interested in the chemical composition of these gases, it is their volume and their physical action which causes us trouble on heavy welds.

✦ ✦ ✦

THE tabulation on the following page (Fig. 21) shows the total gas developed under the Vacuum Fusion method by the electrode metal of 9 of the leading makes of shielded arc electrodes bought in the open market. These 9 makes accounted for 92% of the total sales in 1935. It seems self-evident that when the quality of electrode steel varies to the extent that per 100 gram of metal from a minimum of 5.2 cc. to a maximum of 109.3 cc. of gas is evolved under identical conditions, a real metallurgical problem exists and considerable improvement should be possible.

✦ ✦ ✦

FROM the results obtained through additional tests made by adding 0.1% of powdered aluminum it appeared plausible that in addition to the solute gases of the steel gas was also released through the reaction of solid non-metallic oxides with the carbon or carbides present in the steel.

✦ ✦ ✦

SUSPECTING that oxides may have been introduced into the steel during the hot rolling of the same (a crack in the ingot, a lap in the rod mill and the oxides formed by the quickly scaling hot metal will be forced into the steel) and thereby, materially increasing the total gas content as developed under the vacuum fusion method, a series of tests were made as given in the tabulation in Fig. 22. While the results are not entirely conclusive, they show a very definite trend, that is a steady increase of total evolved gas content from ladle to ingot to hot rolled rod to finished electrode. This would indicate that better metallurgical control of the entire electrode making process such as clean molds, proper cropping of the billets, rolling at proper temperature, the absence of seams and laps in the hot rolled rods, not too drastic reductions in the cold drawing process should produce finished electrodes low in reactive impurities which will cause the explosion-like release of gas when melted under the electric arc.

✦ ✦ ✦

WELDING electrodes are customarily furnished in 14 and 18″ length. When starting, such an electrode will be at room temperature, when about half of its length is melted down, the remainder will have a temperature of from 350 to 400 degrees F. Some practical operators, not knowing anything about the temperature resistance gradient of mild steel wire, complain that certain electrodes get red hot making further welding extremely difficult, whereas another kind stays cool at equal current flow. Between room tem-

GAS CONTENT IN CC. PER 100 GRAMS OF METAL AS DEVELOPED UNDER THE VACUUM FUSION METHOD

Date	Specimen Identification	Ladle Analysis				Ladle		Ingot		Hot Rolled Rod		Finished Electrode		
		C	Mn	P	S	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
8-24-35	1	.16	.64	.017	.026			36.5	11.3	45.0	19.6	46.5	18.0	Average of 9 determinations
9-24-35	2	.07	.36	.013	.034					16.1	1.2	26.4	5.8	Average of 4 determinations
11-29-35	3	.16	.55	.011	.027	4.6	4.2	17.2	5.1	18.8	7.1	35.6	20.1	Average of 4 determinations
12-5-35	4	.18	.49	.010	.027					54.4	7.1	56.2	13.8	Average of 6 determinations
12-5-35	5	.08	.39	.013	.033					28.6	5.6	42.3	17.5	Average of 6 determinations
12-5-35	6	.08	.35	.019	.028			32.4	8.7	55.0	23.78	54.4	10.3	Average of 12 determinations
5-23-36	7					14.0	1.51			69.8	55.6	81.3	47.3	Average of 3 determinations
5-28-36	8					56.8	23.1			94.0	49.0	105.9	74.2	Average of 3 determinations
5-28-36	9					9.8	4.43			47.4	31.4	88.7	29.17	Average of 3 determinations
5-28-36	10					7.3	4.06			72.6	28.4	74.4	31.5	Average of 3 determinations
5-28-36	11					24.32	4.1			32.02	19.3	58.8	21.7	Average of 3 determinations
5-28-36	12					29.28	7.6			53.3	26.2	62.5	27.9	Average of 3 determinations
6-20-36	13	.07	.35	.012	.030	16.4	6.8			47.3	23.9	52.4	28.3	Average of 12 determinations

Figure 22. ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

Total Gas content developed under the Vacuum Fusion Method of competitive shielded arc Type electrodes. March 1936.

Spec. #	Size	Type	Manufacturer	Weight of specimen in grammes.	Gas developed c.c.	Cubic centimeter per 100 Grammes	Remarks
1	3/16 x 14"	gas-shielded	Schenectady V	24.46	10.2	41.8	
2	5/32 x 14"	" "	" P	24.60	17.8	72.3	
3	5/32 x 14"	" "	" P	25.10	27.8	109.3	
4	5/32 x 14"	" "	" P	25.07	10.2	44.5	
5	5/32 x 14"	" "	Grathenal V	25.10	8.2	32.5	
6	5/32 x 14"	" "	" V	25.00	11.9	47.6	
7	1/4 x 14"	Semi slag shielded	" P	25.44	17.8	70.0	
8	1/4 x 14"	" "	" P	25.80	5.8	22.40	
9	3/16 x 14"	gas-shielded	" Straight polarity	25.16	4.5	17.9	
10	3/16 x 14"	" "	" "	25.47	10.2	39.6	
11	3/16 x 14"	" "	East-Cleveland P	25.25	11.0	43.5	
12	3/16 x 14"	" "	" " P	25.81	6.5	25.2	
13	3/16 x 18"	slag-shielded	New York City P	25.35	4.5	17.7	
14	3/16 x 18"	" "	" " " P	25.16	13.2	52.5	
15	3/16 x 14"	gas-shielded	Chicago P	25.23	25.2	100.0	
16	3/16 x 14"	" "	" P	25.04	6.2	24.8	
17	3/16 x 14"	semi slag shielded	Garberton P	25.0	5.6	22.4	
18	3/16 x 14"	" "	" P	25.23	9.6	38.0	
19	3/16 x 14"	gas-shielded	Newburg P	25.63	11.0	43.0	
20	3/16 x 14"	" "	" P	25.27	8.9	34.9	
21	1/4 x 14"	bare	Marquette Steel	25.75	20.0	77.5	
22	1/4 x 14"	"	"	26.65	1.4	5.2	
23	1/4 x 14"	"	South Chicago	25.95	14.2	54.5	
24	1/4 x 14"	"	" "	25.46	1.5	5.9	

Note. V denotes Vertical & overhead Type, P = downward position only

For each Type and make the figures in the column headed "Cubic centimeter per 100 Grammes" are given to the nearest tenth of the unit.

perature and 400° F. the average electrode steel doubles its electrical resistance, which influences to a certain small degree the current flowing in the welding circuit and, therefore, also the depth of penetration and the temperature of the fusion metal. The ideal arc welding electrode should have the lowest possible temperature coefficient that is the highest electrical conductivity consistent with other essential characteristics.

✦ ✦ ✦

STILL (B19) states that the change of resistance of metallic conductors with temperature is approximately according to a straight line law within certain limits of temperature. Thus if 100a stands for the percentage increase of resistance per degree centigrade rise above a given temperature at which the resistance is known, we may write—

where

$Rt = R_o (1 + at)$

R_o = resistance at the initial temperature

t = temperature rise above initial temperature

R_t = resistance at the higher temperature.

✦ ✦ ✦

WHEN t is measured in degrees centigrade and R_o is the resistance at O° C, the value of a for all pure metals is about 0.0042. This coefficient is known as the temperature coefficient of resistance at O° C.

✦ ✦ ✦

ACCORDING to the 1932 issue of the **"Werkstoff Handbuch Stahl & Eisen" (Verein deutscher Eisen—Huttenleute)** the electrical conductivity of chemical pure iron ($10^{-4}x = 10.0\Omega^{-1}$ cm $^{-1}$) is rapidly reduced through admixture of even very small amounts of carbon, manganese and the usual impurities.

✦ ✦ ✦

THE influence of carbon upon electrical conductivity of iron is given in Table B.

IT is specifically stated that there is a definite relation between the shape and uniform distribution of pearlite and the electrical resistance, also that while the resistance of a wire slightly increases through the elongation of the grains through cold drawing, a complete anneal will restore the original value.

✦ ✦ ✦

ALLOYS mainly consisting of mixed crystals have a relative high electrical resistance where the temperature coefficient is rather low as compared with electrode steel. This is the reason why such alloys are eminently adapted for use as electrical heating elements and the like. **Gustar Tammann** (B20) contends that with practically all metals conductivity increases with lower temperatures, at extremely low temperatures this is no longer a linear function, for example silver at —260° C has 50 times the conductivity than at 0° C. In the same sense liquid metals show a tremendous decrease in conductivity, at about 1000° above the melting point theoretically the conductivity should cease. This is not true since metal vapors have a certain limited conductivity. This also explains why metals of high boiling point have also a relative high electrical resistance over the entire range.

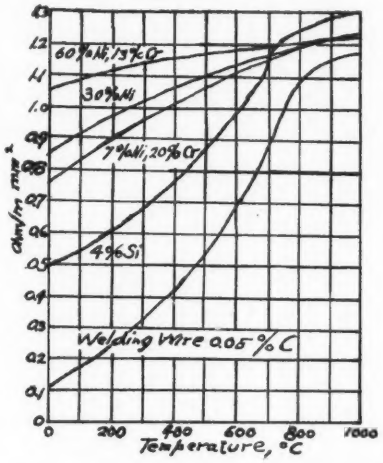

Figure 23. Relation between temperature and ohmic resistance for Welding Wire and wire for heating elements.

✦ ✦ ✦

TABLE B

Carbon Content	Resistance (ohms per mm² per m length)
0.05%	0.1
0.2%	0.11
0.4%	0.12
0.6%	0.128
0.8%	0.138
1.0%	1.45

THE following test results are of interest not only because they show influence of chemical composition and impurity content, but also point out that considerable improvement is possible and desirable in order to flatten the temperature-resistance curve of metal fabricated into arc welding electrodes.

✦ ✦ ✦

THE apparatus used consisted of a 19 plate storage battery connected to delivery 2 volts to a Kelvin Bridge Ohmmeter of high sensitivity which in turn was connected to a 10 foot wire coiled within an insulated furnace heated extraneously with a gas burner so that no products of combustion could enter the test chamber. Temperatures were taken with a laboratory type thermometer placed as near the coil as possible. The resistance readings were taken on the decline as this method seemed to be more accurate for uniform temperature conditions of the air bath.

✦ ✦ ✦

THE formula used for calculating the temperature coefficient as per **H. A. Foster,** Electrical Engineers Pocket Book (page 133, 1913 edition) is as follows:

Let

R_o = resistance at o° F.

R = resistance at t° F.

then

$R = R_o (1 + at)$, a is called the temperature coefficient of the conductor. 100a is the percentage change in resistance per degree F change in temperature.

EXPERIMENT NO. 1

5/32" Welding Wire (in air) Good Commercial Grade
Heat No. 3471—Grade 205—open
C .07, Mn .35, P .014, S .034, Cu .06, Si .01

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0589	.0000
375° F.	.0570	.0019
350° F.	.0548	.0022
325° F.	.0522	.0026
300° F.	.0500	.0022
275° F.	.0477	.0023
250° F.	.0454	.0023
225° F.	.0434	.0020
200° F.	.0412	.0022
175° F.	.0390	.0022
147° F.	.0356	.0034
124° F.	.0348	.0008
84° F.	.0312	.0036

Calculations:—

1° F. = 0.00008768 ohms
1° C. = 0.0001578 ohms
1° F. = 0.00281 Temperature Coefficient

EXPERIMENT NO. 2

5/32" Welding Wire (in air), lapped, defective
Heat No. 3471—Grade 206—open
Analysis—Same as No. 1

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0580	.0000
375° F.	.0570	.0010
350° F.	.0552	.0018
325° F.	.0530	.0022
300° F.	.0508	.0022
274° F.	.0482	.0026
250° F.	.0460	.0022
225° F.	.0440	.0020
200° F.	.0419	.0021
175° F.	.0398	.0021
150° F.	.0376	.0022
125° F.	.0354	.0022
96° F.	.0325	.0029

Calculations:—

1° F. = 0.00008388 ohms
1° C. = 0.0001510 ohms
1° F. = 0.00258 Temperature Coefficient

EXPERIMENT NO. 3

7/32" or 5 gauge rod (in air)
Heat No. 3471—Grade 206—open
Analysis—Same as No. 1

Temp. F.	Ohms Resistance	Ohm Difference
393° F.	.0300	.0000
375° F.	.0298	.0002
350° F.	.0290	.0008
320° F.	.0279	.0011
300° F.	.0270	.0009
275° F.	.0258	.0012
250° F.	.0248	.0010
216° F.	.0232	.0016
200° F.	.0226	.0006
173° F.	.0212	.0014
151° F.	.0202	.0010
125° F.	.0191	.0011
90° F.	.0170	.0021

Calculations:—

1° F. = 0.0000429 ohms
1° C. = 0.00007722 ohms
1° F. = 0.002523 Temperature Coefficient

EXPERIMENT NO. 4

Same as No. 3 except lapped

Temp. F.	Ohms Resistance	Ohm Difference
397° F.	.0306	.0009
375° F.	.0300	.0006
350° F.	.0290	.0010
325° F.	.0280	.0010
300° F.	.0270	.0010
275° F.	.0257	.0013
250° F.	.0245	.0012
224° F.	.0232	.0013
200° F.	.0221	.0011
174° F.	.0210	.0011
150° F.	.0199	.0011
126° F.	.0188	.0011
87° F.	.0169	.0019

Calculations:—

1° F. = 0.0000442 ohms
1° C. = 0.00007956 ohms
1° F. = 0.002615 Temperature Coefficient

EXPERIMENT NO. 5

5/32" Wire (in air)
Heat No. 2860—Grade 405—open High Phosphorus

Temp. F.	Ohms Resistance	Ohm Difference
401° F.	.0587	.0000
375° F.	.0573	.0014
350° F.	.0548	.0025
326° F.	.0524	.0024
300° F.	.0500	.0024
275° F.	.0477	.0023
250° F.	.0453	.0024
224° F.	.0432	.0021
200° F.	.0410	.0022
175° F.	.0388	.0022
150° F.	.0367	.0021
126° F.	.0348	.0019
87° F.	.0316	.0032

Calculations:—

1° F. = 0.0000863 ohms
1° C. = 0.000155 ohms
1° F. = 0.002731 Temperature Coefficient

EXPERIMENT NO. 6

7/32" or 5 gauge rod (in air)
Heat No. 2860—Grade 405—open High Phosphorus

Temp. F.	Ohms Resistance	Ohm Difference
401° F.	.0316	.0000
375° F.	.0306	.0010
350° F.	.0297	.0009
324° F.	.0284	.0013
302° F.	.0273	.0011
274° F.	.0258	.0015
250° F.	.0247	.0011
226° F.	.0235	.0012
200° F.	.0223	.0012
175° F.	.0212	.0011
152° F.	.0200	.0012
124° F.	.0187	.0013
84° F.	.0171	.0016

Calculations:—
1° F. = 0.0000457 ohms
1° C. = 0.00008226 ohms
1° F. = 0.002675 Temperature Coefficient
In other words even a slight increase in phosphor content will decrease the electrical conductivity of electrode steel.

EXPERIMENT NO. 7

5/32′ Wire (in air)
Heat No. 2778—180—High Carbon—killed

Temp. F.	Ohms Resistance	Ohm Difference
401° F.	.0797	.0000
375° F.	.0773	.0024
350° F.	.0750	.0023
324° F.	.0725	.0025
300° F.	.0703	.0022
275° F.	.0681	.0022
250° F.	.0658	.0023
201° F.	.0615	.0021
174° F.	.0593	.0022
149° F.	.0570	.0023
124° F.	.0548	.0022
81.5° F.	.0512	.0036

Calculations:—

1° F. = 0.0000892 ohms
1° C. = 0.00016056 ohms
1° F. = 0.001742 Temperature Coefficient

EXPERIMENT NO. 8

7/32″ or 5 gauge Rod (in air)
Heat No. 2778—180—High Carbon

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0453	.0000
375° F.	.0442	.0011
351° F.	.0430	.0012
324° F.	.0415	.0015
297° F.	.0400	.0015
275° F.	.0390	.0010
250° F.	.0378	.0012
223° F.	.0365	.0013
200° F.	.0354	.0011
175° F.	.0342	.0012
150° F.	.0329	.0013
126° F.	.0316	.0013
93° F.	.0300	.0016

Calculations:—

1° F. = 0.0000498 ohms
1° C. = 0.00008969 ohms
1° F. = 0.001661 Temperature Coefficient

EXPERIMENT NO. 9

5/32″ Wire (in air)
Heat No. 3470—401—High Sulphur

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0730	.0000
375° F.	.0708	.0022
350° F.	.0686	.0022
325° F.	.0663	.0023
300° F.	.0639	.0024
275° F.	.0615	.0024
250° F.	.0593	.0022
225° F.	.0571	.0022
200° F.	.0549	.0022
174° F.	.0531	.0018
150° F.	.0510	.0021
126° F.	.0504	.0006
88° F.	.0454	.0050

Calculations:—

1° F. = 0.00008846 ohms
1° C. = 0.000159 ohms
1° F. = 0.001948 Temperature Coefficient

EXPERIMENT NO. 10

5 Gauge Rod (in air)
Heat No. 3470—410—High Sulphur

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0364	.0000
375° F.	.0358	.0006
350° F.	.0349	.0009
320° F.	.0336	.0013
300° F.	.0326	.0010
275° F.	.0315	.0011
250° F.	.0302	.0013
225° F.	.0290	.0012
200° F.	.0278	.0012
176° F.	.0267	.0011
150° F.	.0252	.0015
124° F.	.0240	.0012
86° F.	.0223	.0017

Calculations:—

1° F. = 0.0000499 ohms
1° C. = 0.00008122 ohms
1° F. = 0.002014 Temperature Coefficient

EXPERIMENTS No. 3 and No. 4 were made with rods of the same analysis as the wire used in experiments No. 1 and No. 2 and are similar in the fact that No. 1 and 3 are in good condition while No. 2 and 4 are lapped being defective rod and wire.

✦ ✦ ✦

THE decrease of the temperature coefficient of the lapped specimen 2 and 4 correspond closely to the respective decrease in effective cross section, remarkable nevertheless is the fact that the defective wire and rod approaches more closely the theoretically correct linear function, whereas the good wire and rod gave a more erratic curve with three distinct peaks.

SAMPLES of wire and rod of high phosphorus content were examined having an analysis as follows: C .04, Mn .14, P .066, S .030, Si .01, Cu .20. See experiment No. 5.

✦ ✦ ✦

SAMPLES were also tested having a high carbon content of the following: Chemical analysis —C .70, Mn .77, P .022, S .028, Si .70, Cu .09. See Experimenent No. 7.

✦ ✦ ✦

THE determinations in experiments No. 9 and No. 10 were made on high sulphur specimens of the following analysis:—C .11, Mn .06, P .034, S .072, Si .05, Cu .16.

APPARENTLY sulphur has a decided effect upon the electrical resistance of wire. The initial and final resistance readings are unusually high for 0.11% carbon welding wire.

✦ ✦ ✦

EXPERIMENTS No. 11 and No. 12 were made using high phosphorus killed steel wire and rod of the following analysis: C .09, Mn .37, P .070, S .039, Si .056, Cu .26.

✦ ✦ ✦

THE next two experiments No. 13 and No. 14) were made with ordinary analysis wire and rod of the following chemical analysis: C .15, Mn .47, P .016, S .038, Si .085, Cu .20.

EXPERIMENT NO. 11

5/32″ Wire
Heat No. 1441—Grade 111—killed, high phosphorus

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0698	.0000
375° F.	.0684	.0014
350° F.	.0663	.0021
325° F.	.0639	.0024
300° F.	.0615	.0024
275° F.	.0593	.0022
250° F.	.0573	.0020
225° F.	.0551	.0022
200° F.	.0531	.0020
175° F.	.0510	.0021
147° F.	.0483	.0027
126° F.	.0466	.0017
90° F.	.0433	.0033

Calculations:—

1° F. = 0.0000855 ohms
1° C. = 0.0001539 ohms
1° F. = 0.001974 Temperature Coefficient

EXPERIMENT NO. 12

5 gauge rod
Heat No. 1441—Grade 111—killed, high phosphorus

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0364	.0000
374° F.	.0355	.0009
350° F.	.0345	.0010
326° F.	.0345	.0010
300° F.	.0324	.0011
275° F.	.0312	.0012
250° F.	.0300	.0012
226° F.	.0288	.0012
200° F.	.0276	.0012
176° F.	.0264	.0012
150° F.	.0252	.0012
126° F.	.0240	.0012
88° F.	.0223	.0017

Calculations:—

1° F. = 0.00004519 ohms
1° F. = 0.00008182 ohms
1° F. = 0.002026 Temperature Coefficient

EXPERIMENT NO. 13

5/32″ Wire
Heat No. 1432—Grade 117—killed

Temp. F.	Ohms Resistance	Difference Ohm
400° F.	.0663	.0000
375° F.	.0656	.0007
350° F.	.0640	.0016
323° F.	.0619	.0021
300° F.	.0600	.0019
275° F.	.0580	.0020
250° F.	.0558	.0022
226° F.	.0538	.0020
200° F.	.0515	.0023
175° F.	.0494	.0021
148° F.	.0470	.0024
126° F.	.0450	.0020
92° F.	.0423	.0027

Calculations:—

1° F. = 0.0000779 ohms
1° C. = 0.0001402 ohms
1° F. = 0.001842 Temperature Coefficient

EXPERIMENT NO. 14

5 gauge rod
Heat No. 1432—Grade 117—killed

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0358	.0000
372° F.	.0354	.0004
348° F.	.0348	.0006
325° F.	.0338	.0010
295° F.	.0326	.0012
275° F.	.0316	.0010
250° F.	.0306	.0010
225° F.	.0294	.0012
200° F.	.0280	.0014
175° F.	.0265	.0015
150° F.	.0254	.0011
125° F.	.0242	.0012
96° F.	.0228	.0014

Calculations:—

1° F. = 0.00004276 ohms
1° C. = 0.000076968 ohms
1° F. = 0.001875 Temperature Coefficient

EXPERIMENT NO. 15

5/32″ Wire
Heat No. 3469—Grade 208—open

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0573	.0000
375° F.	.0558	.0015
350° F.	.0535	.0023
325° F.	.0512	.0023
300° F.	.0490	.0022
275° F.	.0467	.0023
250° F.	.0445	.0022
225° F.	.0424	.0021
200° F.	.0401	.0023
172° F.	.0376	.0025
150° F.	.0360	.0016
126° F.	.0340	.0020
90° F.	.0309	.0031

Calculations:—

1° F. = 0.00008516 ohms
1° C. = 0.0001533 ohms
1° F. = .002756 Temperature Coefficient

EXPERIMENT NO. 16

5 Gauge Rod—Seamy
Heat No. 3469—Grade 208—open

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0314	.0000
375° F.	.0304	.0010
350° F.	.0294	.0010
325° F.	.0281	.0013
300° F.	.0270	.0011
275° F.	.0257	.0013
250° F.	.0244	.0013
225° F.	.0232	.0012
200° F.	.0220	.0012
172° F.	.0207	.0013
150° F.	.0195	.0012
125° F.	.0184	.0011
94° F.	.0168	.0016

Calculations:—

1° F. = 0.0000477 ohms
1° C. = 0.00008586 ohms
1° F. = 0.00284 Temperature Coefficient

EXPERIMENT NO. 17

5/32" Wire
Heat No. 3317—Grade 216—open

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0636	.0000
375° F.	.0610	.0026
350° F.	.0588	.0022
325° F.	.0564	.0024
301° F.	.0544	.0020
275° F.	.0520	.0024
250° F.	.0499	.0021
225° F.	.0477	.0022
200° F.	.0456	.0021
171° F.	.0428	.0028
150° F.	.0411	.0017
120° F.	.0389	.0022
100° F.	.0367	.0022
90° F.	.0358	.0019

Calculations:—

1° F. = 0.002505 Temperature Coefficient

EXPERIMENT NO. 18

5 Gauge Rod—Same analysis as No. 17
Heat No. 3317—Grade 216—open

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0334	.0000
375° F.	.0327	.0007
350° F.	.0317	.0010
325° F.	.0306	.0011
300° F.	.0293	.0013
272° F.	.0280	.0013
250° F.	.0270	.0010
225° F.	.0258	.0012
200° F.	.0247	.0011
175° F.	.0233	.0014
146° F.	.0220	.0013
126° F.	.0210	.0010
88° F.	.0182	.0028

Calculations:—

1° F. = 0.002676 Temperature Coefficient

EXPERIMENT NO. 19

5/32" Wire
Heat No. 1234—Grade 412—Bessemer

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0717	.0000
371° F.	.0690	.0027
350° F.	.0670	.0020
323° F.	.0644	.0026
300° F.	.0621	.0023
275° F.	.0598	.0023
250° F.	.0555	.0043
224° F.	.0537	.0018
200° F.	.0531	.0006
175° F.	.0510	.0021
150° F.	.0489	.0021
125° F.	.0463	.0026
94° F.	.0440	.0023

Calculations:—

1° F. = 0.00206

EXPERIMENT NO. 20

5 Gauge Rod
Heat No. 1234—Grade 412—Bessemer

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0377	.0000
372° F.	.0372	.0005
350° F.	.0365	.0007
325° F.	.0354	.0011
300° F.	.0345	.0009
275° F.	.0331	.0014
250° F.	.0316	.0015
224° F.	.0303	.0013
200° F.	.0290	.0013
176° F.	.0274	.0016
151° F.	.0261	.0013
125° F.	.0250	.0011
100° F.	.0243	.0007

Calculations:—

1° F. = 0.001838 Temperature Coefficient

EXPERIMENT NO. 21

5/32" Wire
Heat No. 2827—Grade 370

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0840	.0000
370° F.	.0820	.0020
350° F.	.0804	.0016
322° F.	.0779	.0025
300° F.	.0760	.0019
275° F.	.0739	.0021
251° F.	.0717	.0022
225° F.	.0693	.0024
198° F.	.0670	.0023
175° F.	.0649	.0021
150° F.	.0627	.0022
126° F.	.0608	.0019
102° F.	.0587	.0021

Calculations:—

1° F. = 0.00140 Temperature Coefficient

EXPERIMENT NO. 22

5 Gauge Rod
Heat No. 2827—Grade 370

Temp. F.	Ohms Resistance	Ohm Difference
400° F.	.0470	.0000
375° F.	.0465	.0005
350° F.	.0456	.0009
324° F.	.0445	.0011
300° F.	.0434	.0011
274° F.	.0420	.0014
250° F.	.0408	.0012
225° F.	.0397	.0011
198° F.	.0385	.0012
174° F.	.0373	.0012
150° F.	.0362	.0011
125° F.	.0349	.0013
103° F.	.0335	.0014

Calculations:—

1° F. = 0.001015 Temperature Coefficient

TWO seamy samples were also tested, one wire and one rod, having the following chemical analysis: C .06, Mn .28, P .014, S .034, Si .01, Cu .06. See eperiments No. 15 and No. 16.

✦ ✦ ✦

THE chemical analysis of the wire and rod shown in experiments No. 17 and No. 18 is: C 17, Mn .52, P .012, S .026, Si .01, Cu —. This compares to regular .14-.19 carbon welding wire.

✦ ✦ ✦

THE chemical analysis of the wire and rod in experiments No. 19 and No. 20 is: C .08, Mn .73, P .073, S .086, Si .021, Cu .22. This steel is high in Mn, P, and S and is similar to Bessemer Steel.

✦ ✦ ✦

EXPERIMENTS Nos. 21, 22 were carried out with wire and rod of the following analysis: C .68, Mn 1.10, P- .025, S .040, Si .196, Cu .20.

✦ ✦ ✦

IT is obvious from the results shown that not only the carbon and manganese as well as the phosphor and sulphur content of electrode steel influence electrical conductivity and temperature coefficient, but also grain size and especially the manner and shape in which the pearlite is distributed throughout the structure of the steel are a deciding factor.

✦ ✦ ✦

THIS seems to be a fertile field for additional research promising such improvements in the quality of electrode steel as seems particularly advantageous to the welding engineer, namely an increase in the electrical conductivity in the steel with a parallel reduction of the temperature coefficient between 50° and 400° F.

✦ ✦ ✦

ON the basis of the foregoing and in order to present also the view point of the practical steel producer, the author was fortunate to secure the assistance of an esteemed friend and co-worker, **Mr. R. S. Simmons**, General Metallurgist, Keystone Steel & Wire Company, who comments as follows:

RAYMOND S. SIMMONS
General Metallurgist, Keystone Steel & Wire Co.
Member, Wire Association.

"SATISFACTORY wire for coated arc welding electrodes can be produced by the regular processes of wire manufacture but high grade wire for this purpose can only be produced by employing extraordinary precautions in all of the manufacturing operations from the charging of a basic open hearth furnace to the straightening and cutting of the wire preparatory to applying the coating.

✦ ✦ ✦

"THE basic open hearth furnace should be charged with heavy melting scrap, and high grade basic iron, preferably in the form of solid pigs. The steel scrap should be carefully selected to insure its freedom from harmful amounts of contaminating metallics and metalloids, which will remain in the steel after the refining period has been completed. The basic iron should be of the best grade obtainable within the following chemical limitations:

Silicon, 0.95% to 1.25%
Manganese, 1.75% to 2.25%
Phosphorus, Under 0.250%
Sulphur, Under 0.045%
Copper, Under 0.030%

✦ ✦ ✦

"SUFFICIENT lime flux should be added to insure a heavy, creamy slag at time of tapping with an FeO content of about 10% to 12%.

✦ ✦ ✦

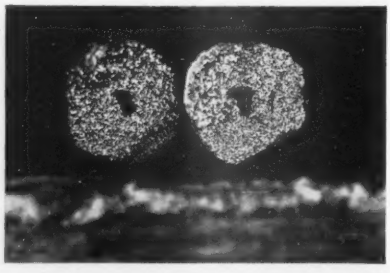

Figure 24. Photograph 101. Fractured Section Showing Non-Metallic Inclusion. (Courtesy Keystone Steel and Wire Company). ✦ ✦

"IF the above procedure is observed in a basic open hearth furnace with proper fuel combustion, a steel will be obtained which will have a phosphorus content of under .015% and a sulphur content of under .035%. If these two elements are much higher than mentioned, it is an evident fact that the steel has not been properly made. Not because the phosphorus and sulphur contents in themselves are high, but because steel melting out high in these two elements is also high in harmful metalloid impurities and occluded gases. The same thing applies to the 0.030% maximum copper content required in the basic iron. A higher content of copper in the iron means that an excessive amount of steel turnings and borings has been used in the blast furnace charge.

✦ ✦ ✦

"NO Deoxidizers should be added to the molten steel during the teeming period, neither in the ladle nor in the molds, other than the ferro-manganese that is added in the furnace just before tapping. This practice will produce an effervescent steel, which, when solidifying, will rim in from the surface of the cast iron molds.

✦ ✦ ✦

PREPARATORY to pouring, the stools and inner surfaces of the molds should be carefully freed from all particles of oxides and silicates which accumulate thereon from previous heats of steel. Otherwise this foreign matter is liable to be entrapped in the solidifying steel."

✦ ✦ ✦

PHOTOGRAPH No. 101 depicts a globule of magnetic iron oxide (scale), found in a defective electrode showing excessively high gas content under the action of the electric arc.

✦ ✦ ✦

MR. Simmons also states that "contrary to the common belief, a highly gaseous electrode can be caused by the magnetic oxide, or scale, which is introduced into the steel during the hot rolling operations. For instance, if the steel at a rolling temperature of approximately 2000° F. should crack in one of the break-down passes of the Blooming Mill, scale would form to the extreme bottom of the crack, and although the crack might be rendered quite invisible by the ensuing rolling, the scale remains embedded in the steel and will cause an excessive gas evolution when melted again in the electric arc.

✦ ✦ ✦

DEEP ragging in the rolls, guides that scratch, and other like conditions will have a tendency

to bury the quickly forming iron oxide into the hot steel.

✦ ✦ ✦

ONE of the major sources of highly gaseous electrodes is present in the rod mills where the square billet is reduced very rapidly to a small sized round called a rod. At the rolling temperature of 2000 F. the metal will oxidize, or scale, as it is rapidly transformed from one size section to another in a modern rod mill. This oxide, or scale, is carried into the steel whenever one particular section is of such an improper shape that it does not allow the homogeneous formation of the next ensuing section. Photograph No. 202 shows scale embedded in the steel due to this condition, also photograph No. 203.

✦ ✦ ✦

THE careful precautions that must be taken in preparing the hot rolled rod for wire drawing are probably well understood because careless work in the cleaning house is reflected in the appearance of the finished wire, and would necessarily be the grounds for the rejection of the wire in any wire mill. Wire for coated electrodes should have a mirror bright finish obtained in different ways most suitable to the conditions peculiar in the different wire mills.

✦ ✦ ✦

SINCE the wire is manufactured free from all lubricant, it is very susceptible to corrosion, and rust, even to the slightest extent, will cause an excessively gaseous electrode. Therefore, the wire must be protected before and after straightening and cutting for any condition that will tend to corrode."

✦ ✦ ✦

CONTRARY to the situation on Coatings for Electrodes, (over 800 U. S. patents are unexpired and still valid) patents issued on electrode steel or the shape or form of electrodes are few. The more important ones are cited in the following:

U. S. Patents covering composition of mild steel electrodes. (Not including alloy steel or non-ferrous metals).

No. 1187411, D. H. Wilson & S. M. Rodgers, June 13, 1916.

No. 1187412, D. H. Wilson & S. M. Rodgers, June 13, 1916.

No. 1363636, P. H. Brace, December 28, 1920 (cored electrode.).

No. 1501266, P. H. Brace, August 17, 1920.

No. 1600856, W. F. Stoody, September 21, 1926.

No. 1794042, A. P. Strohmenger, February 24, 1931.

No. 1930530, D. L. Mathias, October 17, 1933.

No. 2005902, D. L. Mathias, June 25, 1935.

No. 2022307, J. B. Austin, November 26, 1935.

No. 2040189, J. Strauss, May 12, 1936.

✦ ✦ ✦

Figure 25. (Photograph No. 202) 40 diam. Magnification. Unetched Section Showing Oxide Embedded in Steel. (Courtesy Keystone Steel & Wire Company). ✦ ✦ ✦ ✦

Figure 26. (Photograph No. 203) 135 diam. Magnification. Etched Section of Same Flaw as in Illustration No. 25 (Photograph No. 202). (Courtesy Keystone Steel & Wire Company). ✦

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✦ ✦ ✦

CORRECTIONS

THE following corrections to this article were received from the author too late to be made in the text. Please note.

Page 534—The word "tremendous" in the ninth line from the top of the middle column should be "tremendously".

Page 535—At the bottom of the right hand column, "Overhead welding with a 5/32" diameter .05C .16 Mn lightcoated electrode, 95 amperes, 18 volts, left straight, right reversed polarity" is meant for a description of Figure 14.

Page 538—The formula at the end of first paragraph upper left hand column should read as follows:

$$3(FeO \times SiO_2).$$

Page 539—The formula at top of left hand column should read as follows:

$$\frac{Al_2O_3 + SiO_2}{Fe_2O_3 + CO + MgO + MnO}$$

Page 542—Left hand column third line word "mastings" should read "castings". Left hand column, third paragraph, third line, word "sulphuric" should be "sulphide".

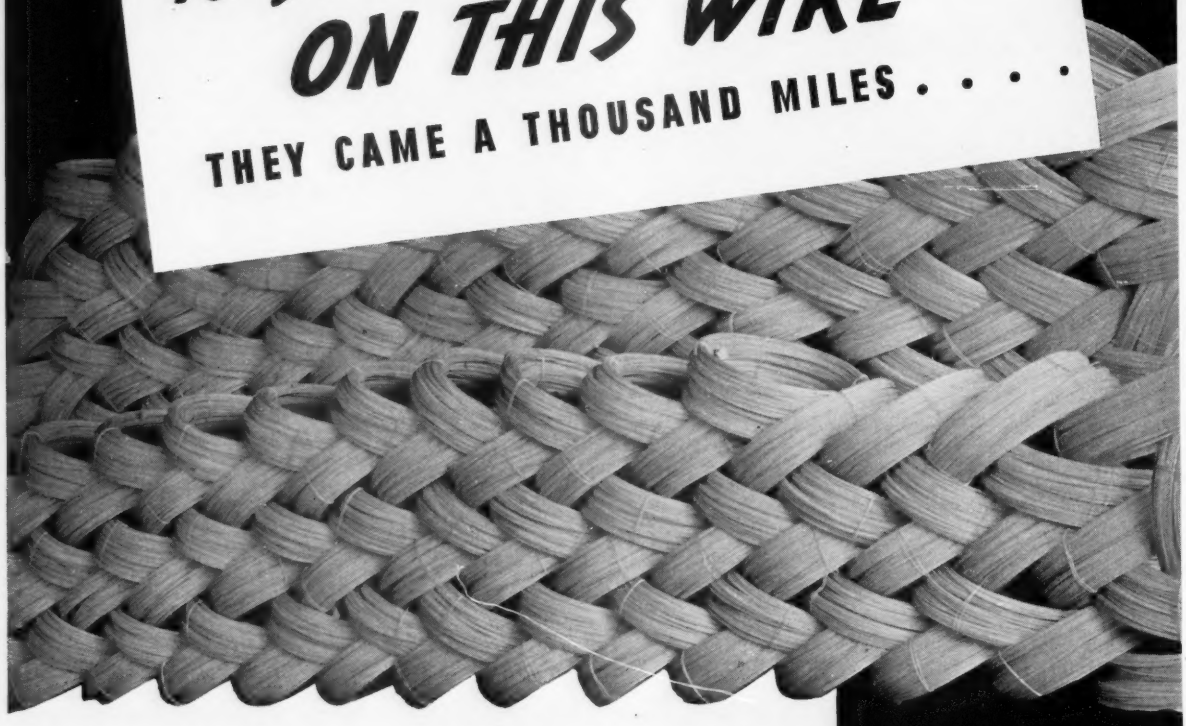
Page 545—Third column, eleventh line from top, word "relative" should read "relatively".

Page 546—Experiment No. 1, second line of caption, "Grade 205" should be "Grade 206".

Page 547—Center column, second paragraph, last line "Si .70" should be "Si 0.170".

To See THE COATING ON THIS WIRE

THEY CAME A THOUSAND MILES . . . .



. . . they clipped and tested specimens from a hundred coils . . . they found a zinc coating unmatched in their experience . . . an electro-galvanizing process proved by months of smooth operation under exacting mill conditions.

These were wire plant executives with an eye to the future, checking the facts first hand. They left convinced. Their order followed. *There is news of prime importance to wire manufacturers and wire users in the perfection of*

MEAKER PROCESS *for*
ELECTRO-GALVANIZING ROUND WIRE

Backed by thirty-seven years' engineering experience in solving electro-galvanizing problems for the Industry. Write or wire for details.

THE MEAKER CO.
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This Process Provides:

- ★ Simplified plant operation.
- ★ Cost equal to or below hot dip.
- ★ Accurate control of coating thickness from 1/20 oz. to 3 oz. per sq. ft.
- ★ Simplified cleaning operation that retains all original physical properties of wire unimpaired.
- ★ High ductility and perfect adhesion, permitting even the most severe forming operations.
- ★ Operation at high current densities producing extremely dense and non-porous coatings.
- ★ Compact, simplified installation.

A Method of Handling Tungsten Carbide Dies Within The Die Room

By K. R. Beardslee, General Sales Manager,
Carboloy Company, Inc., Detroit, Mich.

This paper covers a suggested method of servicing tungsten carbide dies within the die room, outlining economies to be effected through proper handling and selection of dies together with efficient service methods. ✦ ✦ ✦ ✦ ✦

THE die is the only tool used in the wire drawing industry. This tool has been modernized by the use of carbides so that the quality of the finished product has been improved while the cost of the finished product has been reduced. Carbide dies have simplified the accurate holding of customers' specifications without waste or reworks.

✦ ✦ ✦

THE carbide die provides the means of obtaining these results but the degree of realization depends to a considerable extent on the handling of the dies in the die room.

✦ ✦ ✦

IN the mill the die room is established to provide the correct dies when they are needed. The function of the die room, therefore, is twofold. First, the dies must be of the proper quality in order to obtain the maximum production per hole. Second, the quantity of dies available at all times must be sufficient to take care of the normal mill needs without an excessive investment.

✦ ✦ ✦

Part I—Quality

THE quality of the die depends upon the shape and the smoothness of the surface in the die. Manufacturing and servicing the dies allow the mill to rigidly control these requirements within limits which have been established to meet their own problems.

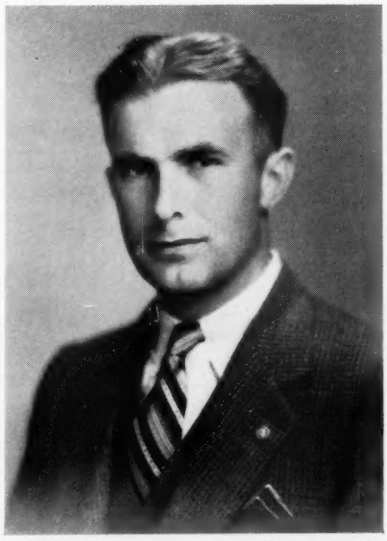
✦ ✦ ✦

THERE are four stages in servicing and finishing carbide dies.

1. Finishing of dies ¼" and under, from moulded nibs;
2. Polishing of dies returned from the mill;
3. Recutting dies that have been worn oversize;
4. Finishing and servicing dies ¼", and larger.

✦ ✦ ✦

THERE is available today adequate equipment for the manufacturing and servicing of tungsten carbide dies. The picture in Figure 1 shows an up to date wire mill die room with the equipment installed that we will now describe.



K. R. BEARDSLEE

General Sales Manager, Carboloy Company, Inc. 1919-1929 Purchasing Dept., International Motor Co., New Brunswick, N. J., 1929-1931 Salesman, Carboloy Co., Inc., Newark, N. J., 1931-1936 District Manager, Carboloy Co., Inc., Pittsburgh, Pa. July 1, 1936 General Sales Manager, Carboloy Co., Inc., Detroit, Mich. Member of The Wire Association.

✦ ✦ ✦

IN order that the nomenclature used in the description of manufacturing and servicing of dies will be understood, you will note that Figure 2 shows the bell front, approach angle, bearing, and back relief. The front opening will be termed the bell; the reduction area, the approach angle; the cylindrical or sizing part, the bearing; and the angle on the back, the back relief.

✦ ✦ ✦

Finishing of Dies ¼" and Under From Moulded Nibs

OUR first example is a die to be manufactured at size .0625" for drawing high carbon wire. Should we follow standard practice of 12° approach angle and two-thirds length bearing with a one thirty second (1/32) back relief, we will find from the chart in Figure 3 that we must allow .015" under our finished size. Therefore, one must start with a 12° tapered hole of .047". (See Figure 3).

✦ ✦ ✦

THE rough nib is then put on a lapping machine, shown in Figure 4, where the 12° approach angle is lapped to size of .047".

✦ ✦ ✦

LAPPING is done with abrasive powder mixed with very little oil. The die should come from this machine with a smooth gray finish free from rings. The pins used

in this machine are made of ordinary soft steel and can be reshaped after they have become worn.

✦ ✦ ✦

THE die is then taken to the polishing machine where it is placed in a collet or chuck and the back relief is lapped in the die. See Figure 5.

✦ ✦ ✦

THIS operation may also be done on the lapping machine using a steel pin with 30° included angle, although some mills prefer to put this back relief in the die with the use of a diamond radius tool.

✦ ✦ ✦

THE bearing is lapped in the die while it is in the collet or chuck. Two laps are selected: — one .003″ under the finished size, and the other the prospective size of the die.

✦ ✦ ✦

THE lap is placed in a Jacobs chuck, and, using the tailstock on the polishing machine as a guide, the bearing is lapped with coarse diamond powder or boron carbide. The die is then cleaned out and the final lap, using a fine grade of diamond powder, is used until the size is obtained. Please note in Figure 6 that the laps should be used from the tailstock of the polishing machine, thereby assuring concentricity of bearing to the O. D. of the die casing.

Figure 1. General View of Die Room.

✦ ✦ ✦ ✦

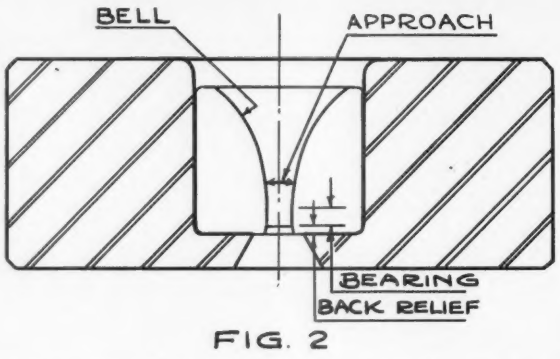


FIG. 2

Figure 2. Sketch Showing Die Laid Out as to Bell, Approach Angle, Bearing, and Back Relief.

✦ ✦ ✦ ✦ ✦

✦ ✦ ✦

LAPS covering all standard sizes should be accumulated and kept in a rack so they may be selected without loss of time as shown in Figure 7.

✦ ✦ ✦

THE die is reversed in the automatic polisher where the approach angle is polished.

✦ ✦ ✦

THE angle pin used in the tailstock of the automatic polisher shown in Figure 8, is the same degree as the approach angle de-

FIGURE 3—CHART FOR CONTROL OF BEARING LENGTHS

Diameter Difference in Thousandths	12°	14°	16°	18°
.001	.0047	.004	.00356	.003
.002	.0096	.008	.0071	.006
.003	.014	.012	.0107	.009
.004	.019	.016	.0142	.013
.005	.024	.020	.0178	.016
.006	.029	.024	.0213	.019
.007	.033	.027	.0249	.022
.008	.038	.032	.0285	.025
.009	.043	.037	.0320	.029
.010	.048	.040	.0356	.031
.011	.052	.045	.0392	.035
.012	.057	.049	.0430	.038
.013	.062	.053	.0460	.041
.014	.067	.057	.050	.044
.015	.072	.061	.0535	.047
.016	.076	.065	.057	.051
.017	.081	.069	.0605	.054
.018	.086	.073	.064	.057

sired in the die. When the approach angle has been lapped smooth, a sharp line is created between the bearing and the approach angle. This line may be blended with the use of the flexible shaft and diamond powder as shown in Figure 9.

✦ ✦ ✦

THE degree of blending of the sharp line between the approach angle and the bearing depends entirely upon the type of wire being drawn. Inasmuch as we are describing the manufacture of a .0625" die for high carbon wire, we will leave this line sharp. The die is now ready to go to the die cabinet for mill use.

✦ ✦ ✦

2. Polishing of Dies

IN order to obtain best results from all dies, they should be cleaned immediately upon their return to the die room from the mill. This may be accomplished by use of a wire brush mounted on spindle shown in Figure 10.

✦ ✦ ✦

ALL dies should then be inspected and segregated as follows:

(a) Dies in good condition returned to die cabinet;
(b) Dies with wear rings in approach angle set aside for polishing;
(c) Dies worn oversize segregated for recutting.

✦ ✦ ✦

IF the wear ring is only slight, the approach angle may be polished in the automatic polishing machine with the use of the flexible shaft. If the ring is heavy, it should be put into the automatic polisher until the ring has been removed. This will necessarily cut down the length of the bearing, but the die may be used until the bearing has been practically eliminated.

✦ ✦ ✦

IT may be well to explain at this time that the bearing in carbide dies wears very little if the approach angle is polished at frequent intervals. Considerable polishing may be done on the approach angle without changing the die size. If this ring is allowed to wear too deep, small pieces of carbide will be removed and pulled through the bearing, causing scratches. In order to properly remove these scratches the die size usually must be increased.

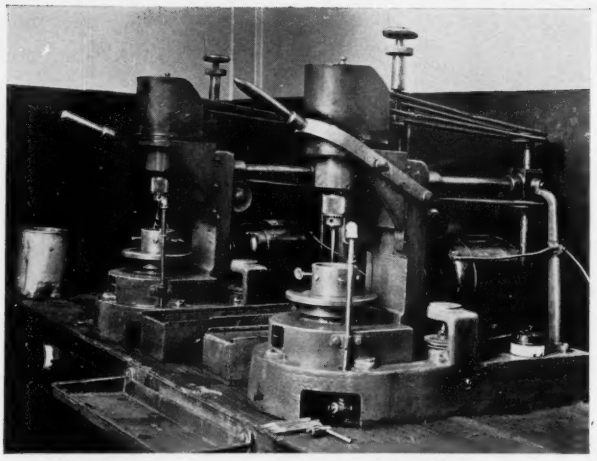


Figure 4. Lapping Machines.

✦ ✦ ✦ ✦ ✦

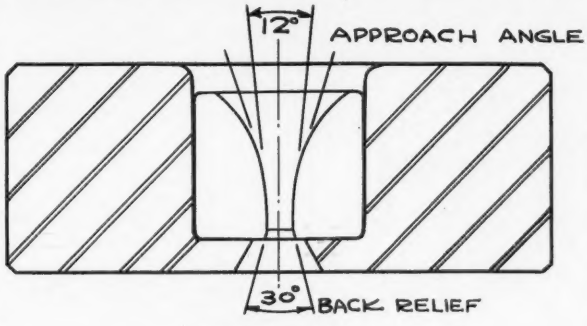


FIG. 5
SHOWING APPROACH ANGLE AND BACK RELIEF

✦ ✦ ✦

AFTER these dies have been polished, they are inspected and returned to the die cabinet for further use.

✦ ✦ ✦

3. Recutting of Dies

ALL dies that have worn oversize or have scratches in the bearing too deep to be removed, should be placed in a rack labeled "oversize". In a mill where more or less standard sizes are being produced, the oversize dies should be placed in a rack showing the next standard size to which they may be recut. The rack in Figure 13, enables the room supervisor to know immediately just how many dies are available for recutting to the next size.

✦ ✦ ✦

THE first step is to lap out the wear ring on the lapping machine to the approach angle desired, and then proceed as in manufacturing a new die.

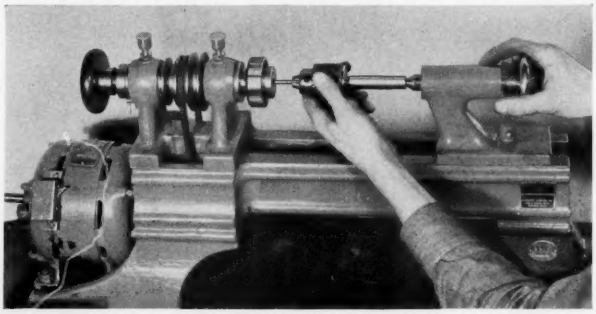


Figure 6. Lapping Bearings.

✦ ✦ ✦ ✦ ✦

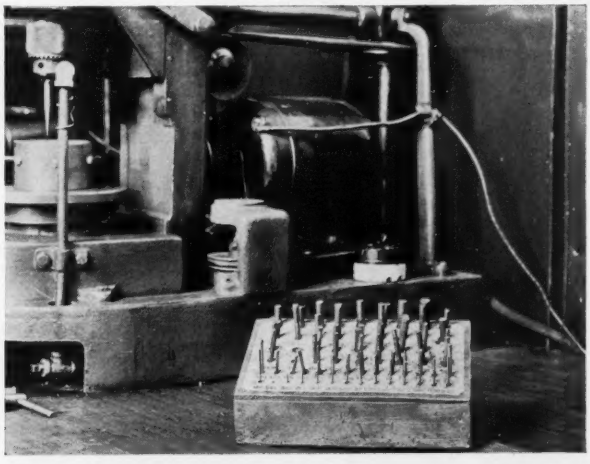


Figure 7. Lap Rack.

✦ ✦ ✦ ✦ ✦ ✦

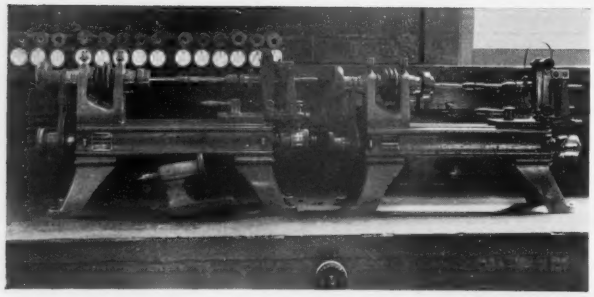


Figure 8. Automatic Polisher.

Figure 9. Die in Polishing Machine With Flexible Shaft.

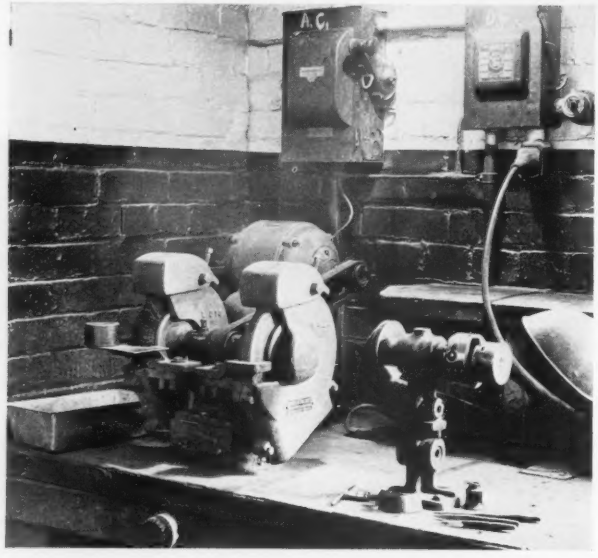


Figure 10. Cleaning Dies.

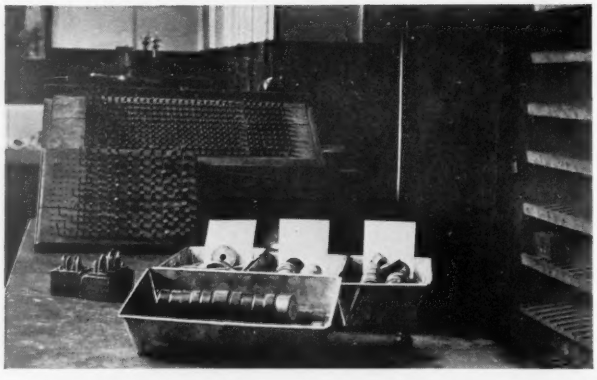


Figure 11. Inspection Table.

4. Finishing and Servicing Dies ¼" and Larger

THE method used on larger dies varies slightly in many mills. The method described will include the use of a 1" precision bench lathe and flexible shaft as shown in Figure 14.

✦ ✦ ✦

THE die is placed in the chuck where the approach angle desired is bored with a diamond boring tool set in the compound as shown in Figure 14. This tool can usually be procured at a price which makes it more economical to use than ordinary lapping methods. The die is shaped by the same method as a steel die is bored. The bearing is bored to within .005" of finished size. This last .005" of carbide is removed by using two laps. The first lap, .002" under size, is placed in the tailstock of the lathe where coarse diamond powder is used. The second or final sizing lap is used with fine diamond powder. The back relief is then diamond bored, sharp lines are broken with the flexible shaft, and the approach angle polished. In order to produce an extra smooth finish, a hard wood stick shaped approximately to the angle of the die, and wrapped with absorbent cotton, is forced into the die. A small quantity of diamond dust and olive oil is used on the stick. This operation improves the finish but does not change the shape or size of the die.

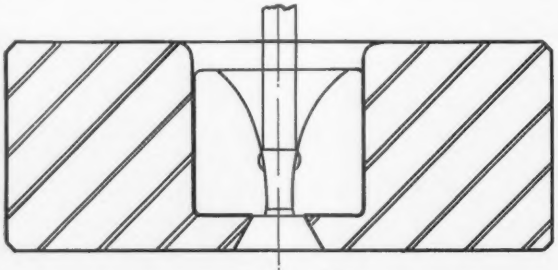


FIG. 12
SHOWING WEAR RING.

✦ ✦ ✦

THE manufacturing technic we have described is one of many that have been satisfactorily used. We would particularly call attention to the fact that bearings and approach angles should be concentric with the O. D. of the die casing. In order to assure this concentricity, the bearing should be placed in the die with the lap properly centered in a tailstock and not held free-hand. Smooth surfaces of approach angles and bearings increase die life.

✦ ✦ ✦

Part II—Quantity

THE proper analysis of any mill's requirements

will save many dollars in original and replacement die investment. Close contact between the scheduling department of the wire mill and the die room will result in obtaining more hole sizes per die nib.

✦ ✦ ✦

AFTER all, it is footage and not tonnage that wears a die. For example, a 300 lb. bundle of .190″ wire contains 3,093 feet, whereas a 300 lb. bundle of .080″ wire contains 16,666 feet. Therefore, it is evident that a mill will need 1/5 as many dies at .190″ as it will need at .080″.

✦ ✦ ✦

THE chart in Figure 15 thoroughly illustrates the proper selection of nib sizes in relation to average tonnage produced.

✦ ✦ ✦

INASMUCH as a complete installation of carbide dies necessitates a considerable investment, suitable cabinets should be provided so each size is readily accessible and accurately classified. The die cabinet in Figure 16, is one of many

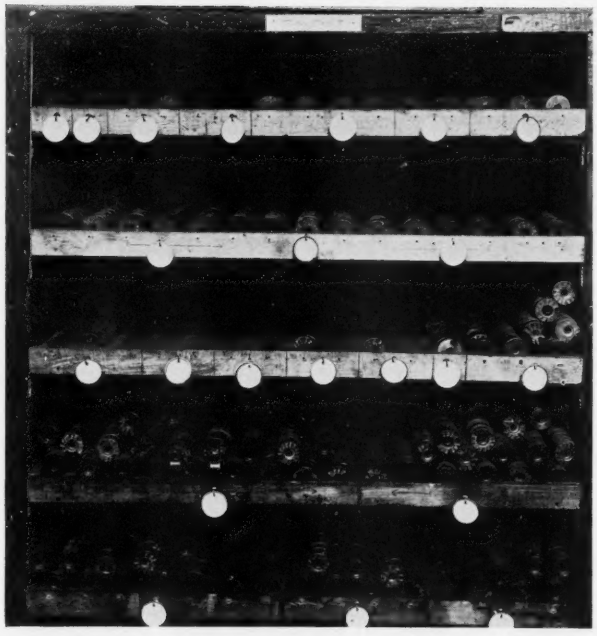


Figure 13. Die Recut Rack. ✦ ✦ ✦ ✦ ✦

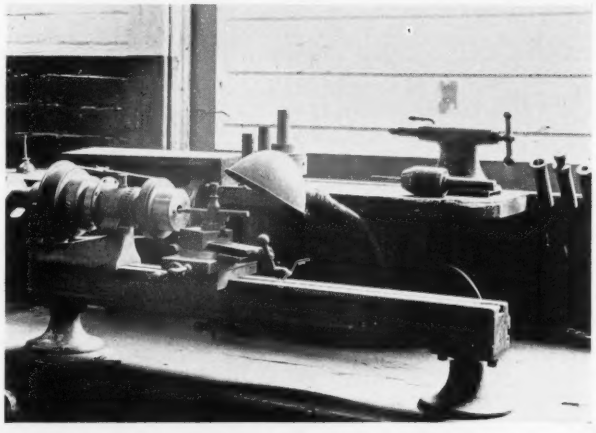


Figure 14. Bench Lathe Compound Set and Die in Chuck. ✦ ✦

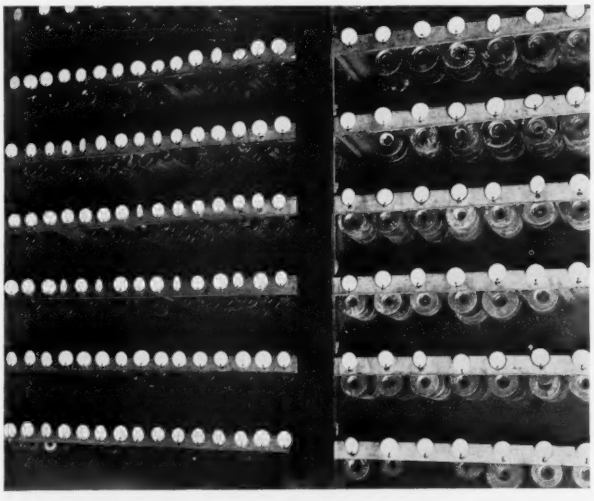


Figure 16. Section Die Cabinet ✦ ✦ ✦ ✦ ✦

that has proven satisfactory. New dies or those returned from the mill may be placed in the rear of each row, and dies sent to the mill taken from the front of each row. This assures rotation of dies and even work up to maximum size.

✦ ✦ ✦

CAREFUL scheduling of operations within the die room will enable the supervisor to instantly check his stock, but what about the quantity of dies in the mill? Where are these dies in the mill and who has them?

✦ ✦ ✦

THE simple record sheet shown in Figure 17, will help to reduce inventory in the mill and prevent the practice of wire drawers keeping favorite sets of dies in their tool boxes.

✦ ✦ ✦

EACH bench or block may be numbered to correspond to a duplicate number in the die room register. The gager or turn fore-

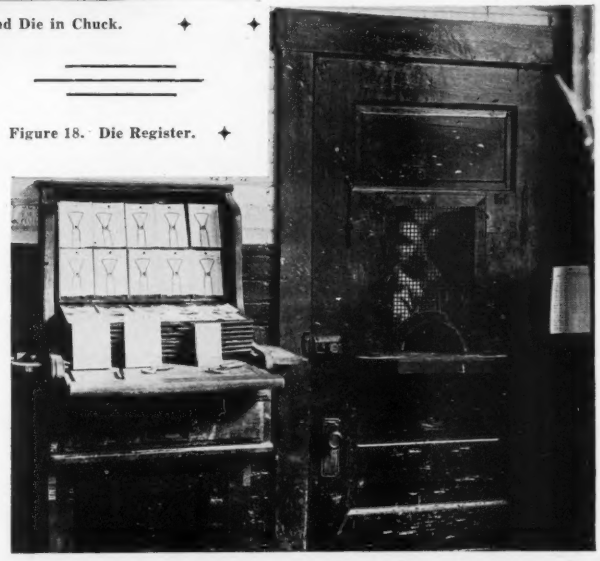
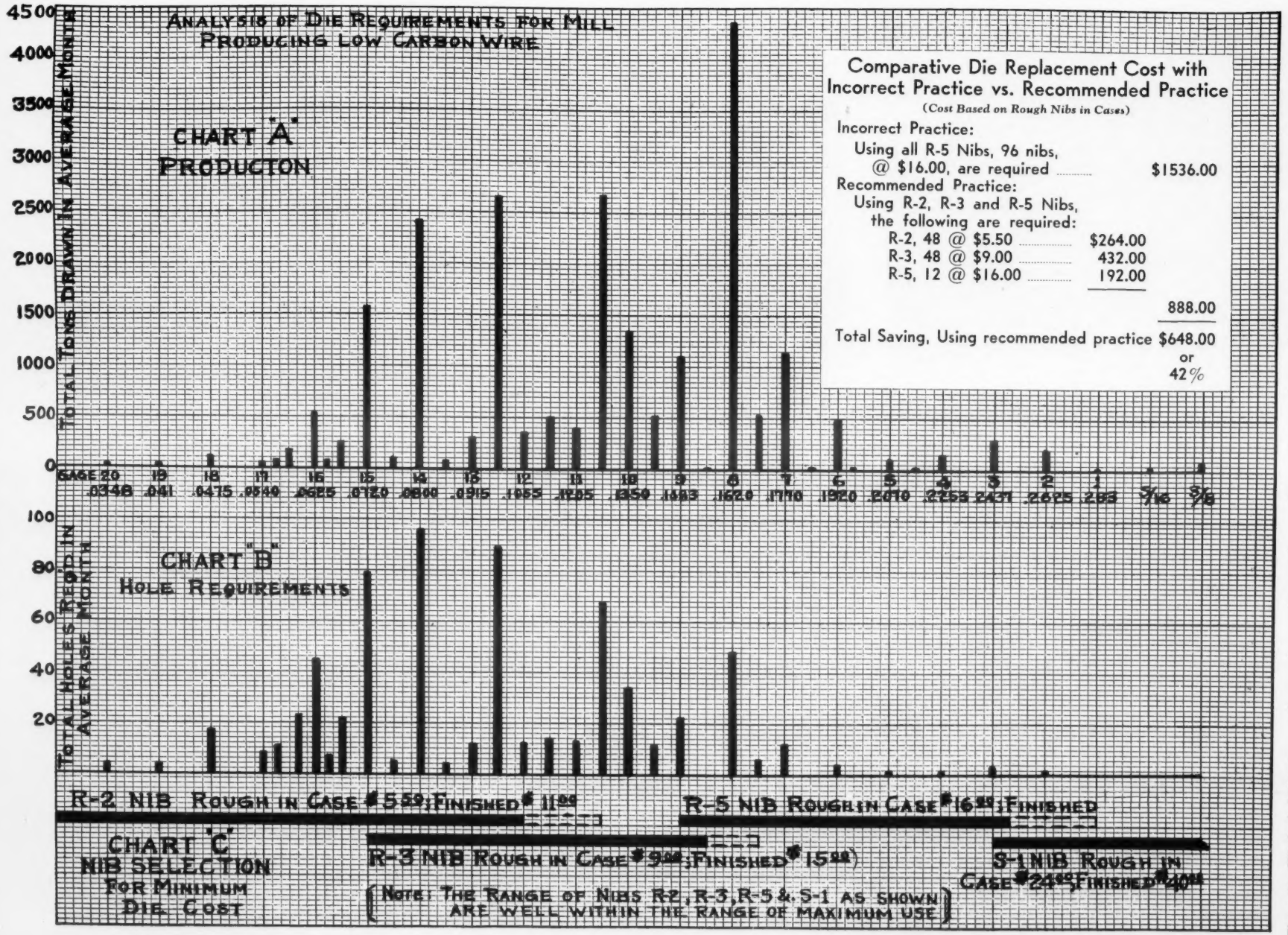


Figure 18. Die Register. ✦


ANALYSIS OF DIE REQUIREMENTS FOR MILL PRODUCING LOW CARBON WIRE
CHART "A" PRODUCTON
TOTAL TONS DRAWN IN AVERAGE MONTH
4500
4000
3500
3000
2500
2000
1500
1000
500
0
GAGE 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 7/16 1/2
.0348 .041 .0475 .0540 .0625 .0720 .0800 .0915 .1055 .1205 .1350 .1483 .1620 .1770 .1920 .2070 .2253 .2437 .2625 .283
CHART "B"
HOLE REQUIREMENTS
TOTAL HOLES REQ'D IN AVERAGE MONTH
100
80
60
40
20
R-2 NIB ROUGH IN CASE @ 55.59; FINISHED @ 11.09
R-5 NIB ROUGH IN CASE @ 16.99; FINISHED
R-3 NIB ROUGH IN CASE @ 9.44; FINISHED @ 15.98)
S-1 NIB ROUGH IN CASE @ 24.19; FINISHED @ 40.14
CHART "C"
NIB SELECTION FOR MINIMUM DIE COST
(NOTE: THE RANGE OF NIBS R-2, R-3, R-5 & S-1 AS SHOWN ARE WELL WITHIN THE RANGE OF MAXIMUM USE)

Comparative Die Replacement Cost with Incorrect Practice vs. Recommended Practice

(Cost Based on Rough Nibs in Cases)

Incorrect Practice:		
Using all R-5 Nibs, 96 nibs, @ $16.00, are required		$1536.00
Recommended Practice:		
Using R-2, R-3 and R-5 Nibs, the following are required:		
R-2, 48 @ $5.50	$264.00	
R-3, 48 @ $9.00	432.00	
R-5, 12 @ $16.00	192.00	
		888.00
Total Saving, Using recommended practice		$648.00 or 42%

Figure 15. Nib Analysis Chart.

man should give each wire drawer a request for dies which is presented at the die room window. This request should show the kind of wire, as well as the tolerance per size. This information may seem unnecessary, but it will enable the die room to obtain more production

FIGURE 17

BENCH NO. 13			CHECK NO. 8621		
Serial No.		Time OUT	IN	Date OUT	IN
6541	.192	9 P	10 A	8/15	8/17
5797	.160	9 P	10 A	8/15	8/17
8151	.133	9 P		8/15	
8680	.133	9 P		8/15	

per hole size and save scrap or redraw wire in the mill.

✦ ✦ ✦

AS each die is delivered to the mill, the wire drawer's number, bench number, size of die and date is recorded on the form shown in Figure 17. This form is then placed in the register shown in Figure 18, to correspond to the bench number at which the die is being used. Although a wire drawer on a different shift may return the die, the bench number always enables the die room to properly check its return and avoid issuing excess dies to the mill.

✦ ✦ ✦

ALTHOUGH some mills still desire to keep individual die records, their value is questionable. The form in Fig. 19 shows a simple method of checking individual die reamers production as well as the economical cutting of dies. If desirable, these sheets may be posted to master card in office to show number of hole sizes obtained per die.

✦ ✦ ✦

THE routine of the die room should be scheduled for continuity of operations. Each die reamer should be assigned a specific operation, leaving a window man available to dispense dies and adjust complaints.

✦ ✦ ✦

CARBIDE die materials have been constantly improved, mill conditions have been made more favorable; therefore, more attention to quality of dies produced and quantity of dies required will lower wire drawing costs.

FIGURE 19—PRODUCTION FORM

TURN 11 to 7A			DATE 8-15-36					
DIE NO.	FROM	TO	DIE NO.	FROM	TO	DIE NO.	FROM	TO
4893	187	193	8814	096	103	9416	074	077
7344	"	"	9355	"	"	9417	"	
7649	"	"	9386	"	"	5382	177	182
7894	"	"	9404	"	"	7922	.....	.....
5128	160	177	9395	088	096	3055	225	235
7558	"	"	9366	090	"	8820	062	071
7698	"	"	9020	092	"	8830	111	120
5335	162	"	8784	074	077	8778	102	111
8720	096	103	8905	"	"	9428	085	090
			8915	"	"			

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Research as Applied to Manufacturing

By C. W. Meyers, Development Engineer
American Steel & Wire Co., Cleveland, O.

Every business needs some form of fact finding and the more complex the industry the more complicated the research facilities and programs a discussion of the factors controlling research work. ✦ ✦ ✦ ✦

RESEARCH it is said, is the careful, diligent and critical examination attendant to the seeking of facts or principles. Years ago the word "research" conjured visions of test tubes, endless odd shaped glass equipment and gadgets galore. Research men strove to maintain an air of mysterious aloofness — a genus apart, so it appeared. Today there is a necessity for research on every hand—it has become a more common line of endeavor. People are becoming more scientific in habits of thought and the research laboratory is a place whence come developments which make this world a more comfortable place in which to live. The aura of mystery and superstition surrounding research activities has entirely disappeared. In the strictest sense of the word, no business however small, can entirely dispense with some form of fact finding. The more complex the industry, the more complicated the research facilities and programs.

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Types of Research

THERE are several types of research, each concerned with its own part in the complete business picture. Research may be of a statistical nature, such as is found in market studies, in financial examinations, in sociological investigations, and in reviews of competitive activity. Research, on the other hand may deal with new materials, new processes and new uses for products. It may deal with physical or chemical aspects of production mechanics. The products of the researcher may be used to avoid mistakes in manufacturing; to reach a solution to customer complaints; to solve recurring periodic disturbances in plant manufacturing routine; or, if it can be afforded, the institution of research programs for the sake of pure science. The present or future aspect of the results obtained must be carefully weighed.

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Responsibility of Management for Proper Research

THE management or executive staff of an enterprise has a definite responsibility in the establishment and maintenance of a research program.

C. W. MEYERS
Development Engineer, American Steel & Wire Co., Cleveland, O.

Graduate, Case School of Applied Science—degree in Chemical Engineering, and Graduate School of Business Administration, Harvard University, Masters Degree in Industrial Engineering. Started in American Steel & Wire Company in 1923—worked as plant engineer. Later transferred to educational work in charge of trades apprentice training for Company. For several years prior to 1931 had charge of sales training course for Company salesmen. Since 1931 has been doing customer contract work on development of new products and new uses for Company products, along with research and development work in Company plants.

MANY times the statement is made that a company's testing laboratory is "taking care of the research." An opinion is ventured here that this "all purpose" laboratory is doing neither job well. In the first place, two different types of man are needed for the two jobs; and in the second place, a laboratory crowded with routine hustle and bustle is not a place conducive to concentration on problems involving research. It is to the best interests of the business, therefore, to segregate the two activities and provide suitable quarters and special equipment for the research element.

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A RATHER common criticism of management refers to the time element involved in the solution of a problem. It is understood, of course, that business is built on a dollars and cents basis and that the executive staff holds its job by virtue of its earning power. It is also known that many problems turned over to research laboratories have the time element as a major factor. These facts notwithstanding, rush orders have been the bane of many a well planned research program. Many details attend the solution of a problem; along with the absolute need for thoughtful consideration of data obtained from experiments. This all takes time. One of the prime requirements therefore, of management engaged in research is patience. Wherever possible the management should try to foresee the need for research and not wait to institute a detailed program of research after the need has arisen.

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Time Requirements

COMPLETE research programs may require a substantial length of time as evidenced by the nine years necessary to solve successfully a problem for a prominent

scale manufacturer. Old scales were too heavy — complaints were coming in from the field. Materials then in use, or newer materials considered for the scale, had to be aged, or the slight variations due to age effect would result in errors in scale readings. The net results of the investigation was the calling in of six separate industrial research groups; the development of an entirely new material; an entirely different optical treatment of scale reading; the construction of new fabricating machinery; and an entirely new understanding of customer color reactions in retail stores — and, a scale that weighed one-third as much as its older counterpart, and looked entirely different.

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Characteristics of a Good Research Man

A GOOD research man must possess certain characteristics that set him apart from his fellow men. He must have personal qualities of confidence, ccuracy, lucidity, brevity, cooperativeness, and an active optimism. It has been said that a good research man is born, not made. If this be true, the selection of personnel is, of extreme importance. Above all, the selection of a research leader should be given careful thought. The leader must have a personality which will be inspirational to his men; he must have a broader general knowledge than his staff; and he should be able to steer men imperceptibly into the main path and away from time wasting and expensive digressions. It must be remembered that research is a fascinating game and there are many temptations to browse in unexplored fields uncovered by work already done on given problems.

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Satisfactory Results Not Always Obtainable

MANAGEMENT must also recognize the uncertainty of obtaining the desired results in a research problem. After all, maybe there is no satisfactory answer. This is not a pleasant fact to consider, nevertheless it remains that an element of gambling attends any venture in fact finding. However, more of a element of gambling attends the failure to make the attempt.

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Executive Direction Essential

THE executive staff should exercise a certain modicum of direction over the research group. It should observe carefully whether or not the schemes considered by the laboratory are practical. Ofttimes an idea, even if worked successfully in the laboratory, cannot be put into a production department and made to pay its way. The raw material or the conversion cost may be so high as to preclude marketing the product in a competitive field.

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IN industries in which many problems are to be considered, the correct allocation of effort is of prime importance. Executive direction, having the entire picture in mind, must synchronize work so that the prime elements of the problem may be segregated. As these various elements are solved, they may then be brought together and placed in their proper position in the picture, each phase being given its correct perspective with relation to the whole. If some such control is not exercised, it is entirely possible that an overlapping of activities will result, with attendant loss of time and money.

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Equipment

MUCH of research at its inception is introspection, reading, and mental piecing together of known facts. Few can concentrate amid noisy surroundigs. Equipment for research is, in many cases, expensive, and for this reason this part of the program is sometimes slighted. Accurate and adequate findings cannot be obtained from makeshift apparatus. It is well to realize, therefore, that the money spent on good equipment will be more than paid back in time saved and in the dependability of results.

Mobility of Attack

ONE of the features which must be considered by those dealing with research is "mobility of attack". Ofttimes, during the course of an investigation there will be a change in market trend, or the raw material situation may change (price or supply availability). Such an occurrence may nullify the value of research being done at that time. In the event of such a happening it is imperative that the program of research contemplated for the older order of things be shifted immediately to care for the newer developments. Executive direction must be such that a change can be made and the attack made from another quarter with a minimum of effort and expense.

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Application of Ideas Developed Through Research

IDEAS developed from research should be put into practical use in the plant as quickly as possible (as will be pointed out later the duty of the laboratory is to turn ideas over to the plant in a workable condition). After the laboratory has put its final approval on a process or machine, the executive in charge must set up ways and means to introduce the new method into producing departments with almost automatic procedure. Sometimes the full advantage of a research development, meaning the prestige of being first on the market, is lost because of the delay and red tape involved in the rapid utilization of the output of the research laboratory.

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Classes of Research

FROM the foregoing it may be inferred that the entire responsibility for results from research activities might devolve upon executive personnel. Such is not the case. After all, the laboratory itself must justify its existence and must show returns commensurate with the money expended upon its inception and maintenance. The duties of the research staff are definite and include such things as determination of type of research to be done, accumulation of pertinent data, investigational efficiency,

and of course, successful completion of as many problems as possible.

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TWO general classes of research are, (1) purely theoretical, and (2) practical. It is conceivable that commercial research groups could at times become so enmeshed in pure theory that an entire staff might center its activity on mental gymnastics. A certain amount of theory and pure research is, of course, necessary and advisable. Unless the laboratory is organized for that express purpose, however, it is well to keep in mind the main objective. The purely theoretical type of investigation is often confined largely to universities, in which case endowments provide for a large share of the expense. Present concern is with the more practical side of research which is prosecuted by companies of moderate size and organized in such a way that more fruitful results may be obtained.

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Rules of Conduct for Laboratories

THERE are no set rules for the conduct of research laboratories. The character of work done and the methods for doing it are dictated largely by the type of industry in which the research is being conducted. Like all business, however, fundamentals are similar for all research. Rules of procedure may, therefore, be discussed and consideration given certain points of general interest applicable to research work in almost any industry.

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RAW materials supply may be quite properly an important research problem. Development of newer, cheaper raw materials or even several raw materials for the same product will always hold an important place in manufacturing. Emergencies may arise which necessitate cessation of manufacturing activity unless a quick change can be made in raw material. In such a case forethought in research planning may be good insurance against plant shutdown.

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THE rubber industry may be cited as a case in point. Although latex is still obtained from natural sources, there have been extensive research programs directed at new methods for the chemical production of rubber.

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Special Investigations

LABORATORIES installed for research purposes may also be used for the special investigation and testing of product specifications. This is especially true in cases in which the specification may be such that to meet it requires expensive handling in the plant, not commensurate with the benefit obtained for either customer or producer. The specification may have been written by a person not thoroughly familiar with manufacturing plant facilities, resulting in uselessly expensive procedure or greatly increased fabricating difficulties. The research laboratory, through its knowledge of technical subjects can be of great aid to both its own company and the customer in the simplification of standards.

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RESEARCH for the purpose of developing new products, or new uses for older products is, of course, a very obvious duty. Increased demands of the consumer for better appearance, more efficient operation and cheaper product has placed a heavy demand on the manufacturer. This demand is usually relayed directly to the research laboratory which may devise new machinery for production or adopt older equipment to the needs of the product. Sometimes the impetus given development by these specific problems results in the manufacturer entering entirely new fields not heretofore touched by his industry.

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RESEARCH laboratories should guard against aimless efforts. A definite problem should be recognized and work done on that basis. This is not always as simple as it sounds. The real problem may be so clouded by extraneous factors that a clear cut statement may be next to impossible. In such a case the mere correct stating of the problem may go a long way toward its ultimate solution.

MUCH work has been done in a great many fields by the army of research men and women in government and university service. It is a wise research director, indeed, who makes what he can of their efforts. Many painstaking data are recorded at great expense, by these workers, which can be used in the solution of many an industrial problem.

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Personnel Training

IT is of definite advantage to lay out research programs and establish laboratory facilities with the end in view that provision be made for the training of men. Graduate scientists and engineers may be hired without much difficulty; but the man who has had some experience in the business of the company for which he is working is doubly valuable. Some form of training in company products and processes gives the research man a much clearer conception of the reasons back of many research problems. He is, therefore, a much greater asset to the organization.

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RESEARCH laboratory personnel is the real basis for success or failure of many projects. Economies in time and money are made by men properly chosen for the job. It is sometimes advisable to mix in a few so-called "hard shell mill men" to act as foils and to provide a different point of view. In any event, the leader should make certain that the research man does not lose sight of the commercial aspect of the problem on which he is working. It is never advisable to work extensively on a product which does not have proper appeal or which cannot be used in the field. Each laboratory should have men who have the requisite specialized knowledge in certain highly technical fields. For example, metallography, X-ray, stress strain analysis, and many other fields, require special study and development for efficient application, but these matters are important ingredients in a metallurgical research laboratory.

Subjects for Research

HOW are subjects chosen for laboratory research? What shall be the source of inspiration? There are many sources for problems—the real problem is how to choose wisely and cull out the less practical suggestions. Customers may suggest ideas for research campaigns. Care must be exercised, however, that the idea is not extremely limited in scope and one which applies only to the one customer. It may have no real value to the concern paying the bill. Many times men within the company's own family, such as executives, contact men or salesmen, have very good suggestions based on personal observations over a wide field. True, the non-technical man may sometimes over estimate the importance of some particular phase of the problem, but by and large it is well to consider with some care suggestions so made. Findings in other fields by members of the research staff may lead to questions which open up entirely new vistas for exploration. This source depends to a great extent upon the ingenuity of the members of the staff and thus can be developed by the leader of the research group. It should be a prolific source of ideas. It has been found desirable, by certain research groups, to contact university groups and utilize the facilities of the university for training of men and for the use of more highly specialized type of equipment found in university laboratories.

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Department Organization and Operation

THE actual organization of a department to be devoted to research presents many detail problems. It is assumed, of course, that a research director is to be appointed. Whether he be an official of the company or not is a matter for individual handling. In any event, he should have authority to consummate deals and obtain equipment necessary to the conduct of the research laboratory. The number of specialists and laboratory workers depends on the scope of the work being done. Intelligent direction can overcome a lot of handicaps seemingly imposed by lack of working force. It might also be desirable to include on the staff an expert cost accountant and a good engineering draftsman. Reasons for these last mentioned additions will be brought out shortly.

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RECORDS form a very important part of research laboratory procedure. It is imperative that details of experiments, cross reference (with respect to allied projects), chronological procedure, and costs be kept with accuracy.

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OFTTIMES a production department criticizes the research laboratory because machines, devised by the laboratory for production jobs do not always function properly when installed in a manufacturing department. A method for eliminating this difficulty may well be considered.

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EQUIPMENT involving new departures might be constructed full scale (unless of too massive a nature) and installed right in the laboratory. It is desirable to have the engineering draftsman work with the specialists and laboratory technicians in the construction of this equipment. The resulting equipment is therefore in the nature of a "pilot" installation, used to eliminate "bugs" so commonly encountered in new projects. After the installation is made to operate successfully it is the duty of the cost accountant (a staff man) to prepare complete cost data on the operation of the new machine. It is possible, in this way to obtain all drawings, construction and cost information necessary to efficient production operation of the equipment.

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UPON the completion of this work the machine may be sold to the plant for cost of material plus a prearranged share of development expense. The plant would thus obtain a first-class piece of equipment, ready to operate on production schedules and be entirely free from the expensive "breaking in" practice so common to new installations. If necessary, part of the laboratory staff could be drafted into the plant to instruct the plant operating men.

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IN the case of more bulky equipment or developments representing only partial changes in existing practices, it is possible to adopt somewhat similar tactics. In any event, the disruption of a producing department must be kept at a minimum. Possibly "scale" models could be built so that closer correlation might be obtained between the laboratory and the plant.

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Conclusion

RESEARCH is economically sound. It is one of the most powerful tools of scientific management. Industrial development, in any field, depends upon the technological improvement resulting from properly administered research activities.

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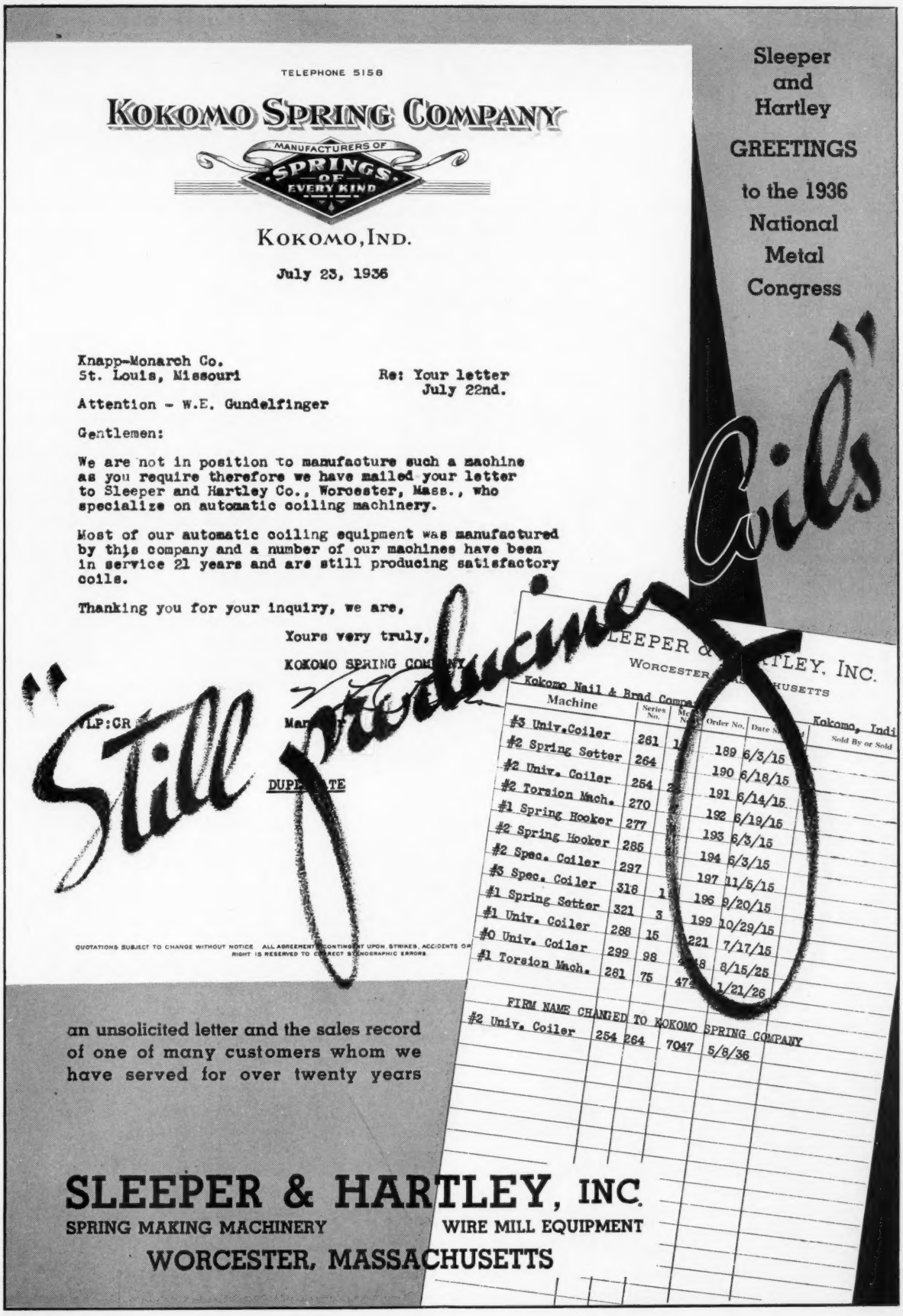
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Tungsten Carbide and Its Application To Dies and Tools

By A. R. Zapp, Manager, Firthaloy Division,
Firth-Sterling Steel Company, McKeesport, Pa.

The discussion in this paper is necessarily confined to dies and tools used in the drawing, fabricating and forming of wire and products made of wire. The improvements in carbide material and present-day requirements for special grades of tungsten carbide are discussed.

A STUDY of the various carbides and their application to dies and tools covers such a wide range that necessarily this paper must be confined to the discussion of dies and tools pertaining directly to wire. This will eliminate any reference to tools used in the machine tool and allied industries. This article, therefore, will deal only with the tools and dies used in the drawing, fabricating and forming of wire and products made of wire.

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THE field for tungsten carbides, with and without the additions of other metallic carbides, has been considerably expanded during the past few years, and there is reason to believe that their usefulness will increase considerably faster in the future due to the knowledge which has been accumulated to date as a result of correlating intensive research in the laboratory with practical data collected in the field.

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MOST of us are familiar with the difficulties encountered when carbide dies were first introduced into the wire mill, and their present success can largely be attributed to improved die design, the application of correct lubricants, perfected casings to properly support the nibs and improvements in the tungsten carbide itself. Another important contributing factor has been the generally improved mill practice.

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Sintered Carbides Have Opened New Metallurgical Field

SINTERED carbides, since their introduction, have opened a new metallurgical field which in turn has branched into three methods of manufacture, namely, casting, hot pressing, and sintering. We shall attempt in this paper to deal with only this latter method of manufacture by the process of sintering.

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MUCH in common with developments in the steel industry, which originated with the Bessemer converter, gradually evolving to the Open Hearth and electric furnace, tungsten carbide has gradually developed during the last decade from merely an "all purpose" material into a number of specialized grades of tungsten carbide, each developed primarily for a particular use or application.

A. R. ZAPP

Attended Franklin & Marshall College, The United States Naval Engineering School, and Stevens Institute of Technology. Served two years as Engineering Officer in U. S. Navy. Five years in the Research Division of the Allied Chemical and Dye Corp. Four years with the Reily-Stoker Corp. Three years with Union Wire Die Corp. From 1932 with the Firth-Sterling Steel Company as manager of the Firthaloy Division. Member, The Wire Association.

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Forming Sintered Carbide

SINTERED carbide basically is formed by carburizing metallic tungsten with some form of carbon. To this "tungsten carbide" a binder, usually cobalt, is added to form a matrix to cement together the minute tungsten carbide particles. This binding medium is added in various proportions to obtain certain predetermined characteristics of hardness and toughness. This mixture of tungsten carbide and cobalt is combined with a lubricant — which, however, is later dissipated in the process of sintering—and pressed into any desired size and contour. The blank or nib thus formed is stoked into a hydrogen - atmosphere sintering furnace and subjected to the exact heat required for proper sintering over a definite length of time. To obtain the desired physical characteristics and control grain size, however, the cooling of the sintered carbide must be regulated by a definite schedule precalculated for that particular grade.

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Early Investigations of Tungsten Carbide

LIKE other new materials, tungsten carbide passed through a comparatively slow stage of development while basic information was being gathered and evaluated. Through the cooperation of the wire industry with the manufacturers of sintered tungsten carbide dies, the necessary fundamental data with regard to correct shapes, speeds, lubricants and other variables were collected and catalogued. By means of this inquiry and research into the problems confronting the application of sintered carbide to the wire industry it became apparent that the one or two

grades known at that time could not properly fulfill the wide range of requirements existent. This necessity for new grades led to the introduction of new and improved types of cemented tungsten carbide, together with grades containing varying proportions of tantalum and titanium carbides.

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IN order to obtain the necessary basic data with regard to shapes and performance it was necessary to limit the earlier experiments to a few standard grades because different combinations with their different physical properties appeared to require slightly modified shapes and exhibited dissimilar characteristics when performing the same operation. Therefore, until recently most dies were made from grades containing either approximately 6% cobalt or about 13% cobalt as a binder, the 6% material being used when a hard grade was desired and the 13% material when a tough grade was required.

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DURING the first years of application of the two grades a number of variables in the material were noted that tended to restrict the use of carbide dies. The material varied a great deal in toughness as shown by transverse rupture tests, and none of it was sufficiently tough to make large dies satisfactorily. Moreover, most of the dies showed porosity of one type or another which often made them unsuitable even when other conditions were probably correct. At the present time the toughness has been considerably improved and both toughness and porosity are controlled within narrow limits and can be varied at will.

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Later Improvements

MOST of the later improvements in carbide dies have been achieved through careful selection and preparation of raw materials such as tungsten, carbon and cobalt, as well as all other materials used, together with various refinements in the processes of manufacture of the nib from the raw materials. For example, in the case of tungsten which is usually the main constituent of cemented carbides a more uniform product is produced when the ore can be handpicked from one constant source than when it must be purchased in the open market where all types are mixed, making it impossible to buy exactly the same quality at all times. Tungsten occurs in three types of ores, viz., Ferberite, Wolframite and Scheelite. Our experience at the present time indicates Ferberite produces a superior tungsten carbide for die making.

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Preparing the Powder

THE grinding and mixing of the powders is approximately the same as it was originally, with the exception that more care is exercised to insure a uniform product. A powder of a certain grain size and structure that is correct for one grade of material may not be proper for another grade, notwithstanding the fact that the chemical analyses of the two materials are practically identical. Through careful manipulation of the basic powder, grades that possess different properties can be produced, tested and duplicated, since the grain size of the basic powder has been found to greatly influence the hardness and toughness of the finished die.

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THE carburizing process has been slightly changed to produce a more uniform carbide. The practice we employ is to ball mill the carbide combinations with metallic cobalt, varying the grinding practice to suit the various grades produced.

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Moulding and Sintering the Powder

THE prepared powder is pressed to shape in steel molds and then sintered. Considerable care is exercised to eliminate any variation in the pressing operation to produce sound nibs free from cracks, strains, cones or other nonuniformities. A lubricant is added to the material just before it is pressed so that it will flow in the mold and thereby reduce any differences in pressure to a minimum. The carbide powder with the binder but without some additional lubricant will not flow readily in a mold during the pressing operation, with the result that the pressed piece may be packed harder in one part than another unless the powder is distributed absolutely uniformly into the mold. The pressure has a direct bearing upon the amount the pressed piece will shrink, and consequently a piece pressed with varying density will shrink more in one part than another, producing internal ruptures which may not be visible on the surface.

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THE sintering operation is the same as in the past with the exception of refinements with regard to certain definite predetermined cycles for nibs which are to be used for definite applications. There was a time when large dies and small dies were sintered together for an equal length of time at like temperatures. Dies are now sorted for both size and grade, and are sintered separately to produce individualized results.

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Other Grades of Die Materials

IN addition to the improved quality of dies made from straight tungsten carbide and cobalt, other grades containing tantalum, titanium and other rare metallic carbides with special binding materials are now being made to meet the demands for diversified requirements. Many of these grades are still relatively new, and while at the present time we do not have sufficient data to establish a clear line of demarcation it is only reasonable to assume that these new materials will increase the field of usefulness for carbide dies and tools.

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Die Sizes

SINCE tougher materials can now be produced it is possible to make much larger dies than was formerly the case. In the past it was not possible to produce dies with an outside diameter greater than 2-½" O. D. x 1-¼" in height due to difficulties encountered both in pressing and sintering. Such large dies made by the old methods did not possess sufficient strength and hardness to be of much value to the trade. As a result of these difficulties most of the dies then

manufactured were less than 1-½" O. D. x 1" in height. It is gratifying to know that dies are now being made successfully in sizes up to and including 4" O. D. x 2-½" in height. It is safe to predict that dies up to 12" O. D. by practically any height desired up to 8" will be available in the near future. Thus, the field of usefulness for carbide dies is constantly being expanded so far as size is concerned.

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Progress in Research

THE improvement in carbide material as a result of constant research is reflected by a direct comparison of the physical properties of the original die materials with the latest developments, each containing the same amount of cobalt binder. Table 1 will illustrate the progress made to date.

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IN addition to the improvement in physical properties as shown above, the finished product is now held within much closer limits with regard to grain size. Numerous other grades are being produced containing different amounts and types of binder, definitely controlled grain structures, and various metallic combinations, offering a wide range of materials from which dies can be procured. The physical properties of these dies can be made to vary from a hardness of at least 80 RwC (with a resistance to transverse rupture of more than 200,000 pounds per square inch) to a hardness of 67 RwC (with a resistance to transverse rupture of well over 400,000 pounds per square inch).

TABLE 1

Original	6% Cobalt material	73 RwC	14.50 Sp Gr	175,000#/Sq In R. T. R.
Modern	6% Cobalt material	79 RwC	14.95 Sp Gr	230,000#/Sq In R. T. R.
Original	13% Cobalt material	69 RwC	14.20 Sp Gr	220,000#/Sq In R. T. R.
Modern	13% Cobalt material	73 RwC	14.35 Sp Gr	300,000#/Sq In R. T. R.

Note: "Sp Gr" implies: "Specific Gravity"
"R. T. R." implies: "Resistance to Transverse Rupture"
"RwC" implies: "Rockwell Hardness, "C" Scale"

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Requirements for Special Grades Of Tungsten Carbide

PREVIOUSLY in this paper you may recall we mentioned that the problems confronting the practical application of carbide to more than just a few of the operations in the wire industry demanded the conception of new grades. That this was a pertinent need can be understood by delving into all the phases of drawing steel bar and wire alone. It was obviously impossible to realize efficient performance with one grade of carbide when it was subjected to drawing both low and high carbon steels coupled with the fact that this drawing was performed using either wet or dry lubrication. This, however, was but one question which could be answered by various grades as the solution. Other recognized demands were the necessity for new grades that would ensure proper performance of carbide dies in the extruding of bolts, burnishing of nuts, sizing operations, coating of welding wire, eyelet and ferrule work. Enlarging upon this, we can go on to say that dies for sweging, tube drawing and mandrels, arbors, bumpers, guides, spacers, cutoffs for spring coiling, and other special jobs, presented a further need for new grades. We need not mention that the drawing of copper, brass and other nonferrous metals, together with their alloys, were in a distinct class of their own, challenging us with their own peculiar, special problems.

✦ ✦ ✦

THE problems confronted by the makers of carbide cutting tools for the machine tool industry have also resulted in an assortment of highly specialized grades differing in many respects from those required for the wire industry, and sufficing in themselves to write a chapter in the history of carbide manufacture.

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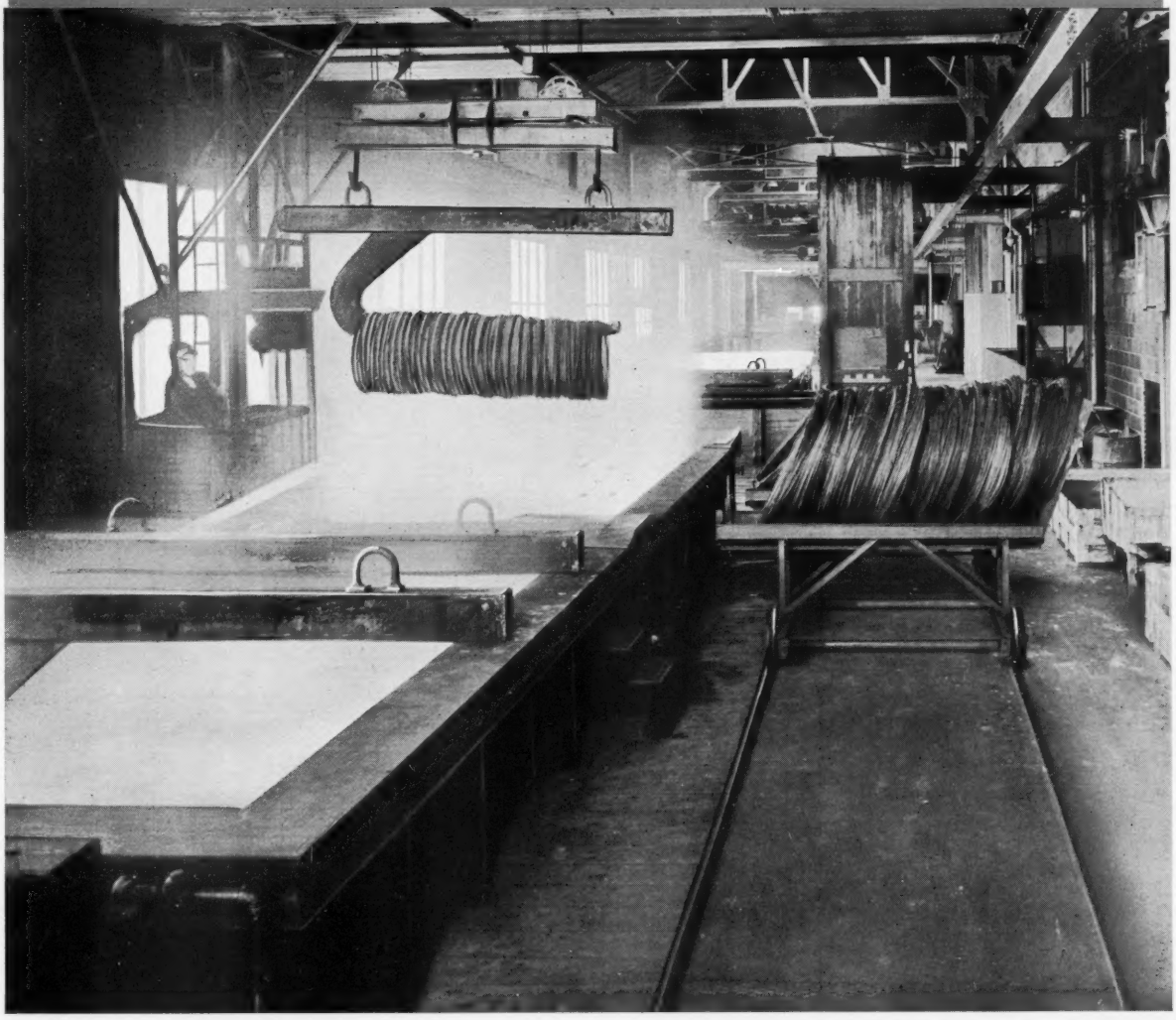

Courtesy of The B. F. Goodrich Co.

The above picture shows 2 wire pickling tanks 15 ft. long, 10 ft. wide, 6½ ft. deep, installed December, 1935, in one of the New England steel mills.

The tanks are rubber-lined steel, protected on the inside with a double sheathing of Acid Brick and BASOLIT.

The installation illustrated is one of many hundreds where BASOLIT has contributed toward long life and efficient operation of modern pickling equipment.

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Cleaning Houses In The Wire Industry

By A. F. Anjeskey, Sales Manager,
Cleveland Tramrail Division, Cleveland Crane & Engrg, Co., Wickliffe, Ohio.

A discussion on cleaning houses, covering the layout of an ideal cleaning house from the standpoint of physical dimensions, type and arrangement of tubs, suggested method for storing and measuring acid, and type of materials handling equipment used, together with illustrations of the trend toward the installation of the straight line cleaning house. ✦ ✦ ✦ ✦ ✦

THE wire industry generally speaking has made many improvements in the manufacture of wire and many plants have accepted such improvements.

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CONTINUOUS mills for rolling rod, improved furnaces with the latest devices for temperature control, carboloy and tungsten carbide dies, for drawing wire and high speed drawing frames, have all made possible the production of wire at low cost with improvement in quality.

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MATERIALS handling equipment has also contributed its share in reducing costs, as it cannot be denied that the most efficient production unit will not maintain its production, unless suitable means are provided for moving the raw or semi-finished material to the unit and removing the finished product from same with handling equipment. Improved processes of manufacture are closely linked with materials handling, each in a way serving the other.

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HOWEVER, with all the above mentioned manufacturing improvements in the industry, in my opinion, the cleaning house in many wire mills is one department which receives very little attention from management, either because management is overlooking the possibilities of reducing cleaning costs, or because the conditions in a cleaning house are accepted as such, due to the use of acid, water, steam and lime, and cleaning operations are performed in a space generally set aside from the balance of the plant.

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FOR many years the circular type or layout of a cleaning house was considered the most practical from an operating standpoint, and this undoubtedly was because labor was cheap and materials handling was not considered seriously as a factor in the cost of production. Many plants still using this type of layout can profitably rebuild their cleaning houses and adopt the straight line type of layout which offers advantages from a materials handling standpoint, in that rod or wire to be cleaned can be delivered at one end and removed after cleaning from the other end. This eliminates congestion as material is not brought to or taken away at the same point as with a circular layout.

A. F. ANJESKEY

Studied electrical engineering, taking night courses in Milwaukee, Wisconsin, and for a number of years was connected with the Allen-Bradley Company in Milwaukee in the Test, Engineering and Sales Departments. Since 1920 with the Cleveland Crane and Engineering Company as District Manager, New York Office. In 1923 transferred to the Tramrail Division, and since 1926, sales manager with headquarters at Wickliffe. Member The Wire Association.

✦ ✦ ✦

Straight Line Cleaning

A STRAIGHT line layout requires less building width, (as little as 16 feet is all that is necessary) and with proper planning for expansion additional tubs for pickling, rinsing or lime coating can always be placed as required. A circular type layout does not lend itself to such expansion unless the arrangement of tubs is made with a larger diameter layout leaving spaces which permit placing additional tubs at a later date. By increasing the radius of the layout a building of greater width and cost is necessary, and such building is more difficult to ventilate and, as mentioned before, the problem of handling materials is not simplified if the ultimate capacity of the large ring is reached.

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IT is true that more than one circular layout can be installed, but this necessitates separate handling equipment for each circle. With a straight line layout duplicate handling equipment can be installed, either of which can operate over the entire cleaning line.

✦ ✦ ✦

THE straight line layout has been installed in enough plants in the last few years to warrant its consideration on any new proposed cleaning house project, and I shall attempt to discuss those installations with which I am familiar.

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FIGURE 1 shows a plan of an installation in a bolt and nut plant with the layout planned for a maximum capacity of seventy-five tons of rod per day. This in-

stallation was made in 1932 and is now cleaning about fifty tons per day. It replaced a circular layout requiring five men for operating the steam crane and handling material to and from the cleaning circle. Only one man is required on this straight line layout and in addition to operating the single leg gantry crane the operator also attaches and detaches a load of rod or wire on the cleaning house hair pin hook from storage buggies which are located at each end of the line.

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AS will be noted at the extreme end of the layout, loaded buggies are carried "in stock" and the crane operator standing on the operating platform between gantry leg, moves the single leg gantry crane to the center line of the storage buggies, and the hair pin hook on the crane, having been lowered to the proper elevation, permits threading the rod off the buggy onto the hook as the operator pulls the buggy toward the leg of the gantry crane. This is easily done, as it is possible for him to step on and off the operating platform.

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I WILL describe in more detail the construction of the crane later. After threading a load of rod on the acid hook, the operator steps on the platform and moves the crane to any one of four positions over the acid tanks and lowers the loaded hook into the acid. It is assumed that the other spaces in the acid tanks have been loaded similarly with pinsfull of rod, and after the rod has been pickled a sufficient length of time, generally from twenty to thirty minutes, the operator runs the crane over the particular pinfull that is pickled, lifts it out of the acid, transports it to the rinse tank, from thence to the sull rack, or if no sulling is necessary, to the lime tank and finally to the buggy at the extreme left end of the layout.

✦ ✦ ✦

HERE the rod is slipped off the hook manually, by the operator who also pushes the loaded buggy into the baker. This is done by revolving the buggy on the turntable so it points in the direction of the baker. It may appear that this manual work by the operator may be fatiguing but it is not, as the buggies are provided with wide flange wheels and anti-friction bearings which with a short movement of the buggy enable the operator to do this work without tiring.

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HAVING pushed a load into the baker the operator returns to his operating platform on the gantry crane, travels to the other end of the line, picks up another pinfull of rod and places it in the acid tank just cleared of the previous load. In this particular plant two thousand pounds of rod are handled on one pin. Production with two tanks of two pins capacity each, is twelve tons per hour and this production could be doubled and still enable the one operator to do all the work. The actual time that a crane is in operation in performing the various functions of handling is slightly over three and one-half minutes. The maximum distance it is required to travel is the distance from one end to the other and back, which is approximately one hundred sixteen feet in each direction, but the distance is cut down to some extent after the cleaning cycle has begun.

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THERE are many interesting details in the layout and construction of this particular cleaning house which I believe are of interest. The acid tanks are set in the floor about half the depth of the tank. These are made of a concrete shell lined with acid bricks and set in Basolite. As will be noted on the plan, two tanks of two pins capacity are set close together, but with a 1" space between to permit for expansion and contraction.

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THE concrete shell has nine inch walls and the inside is lined with three layers of 8½ x 4 x 3½ bricks for bottom construction and two layers of brick for sides and ends. The tanks have an inside dimension of six feet wide by eleven feet long and seven feet deep with an approximate twenty-five hundred gallon acid solution capacity.

✦ ✦ ✦

SPECIAL attention was given to tank drain and overflow protection. The drains are of three inch Duriron sealed in the brick and concrete with Basolite with Duriron taper type plugs to prevent leaks.

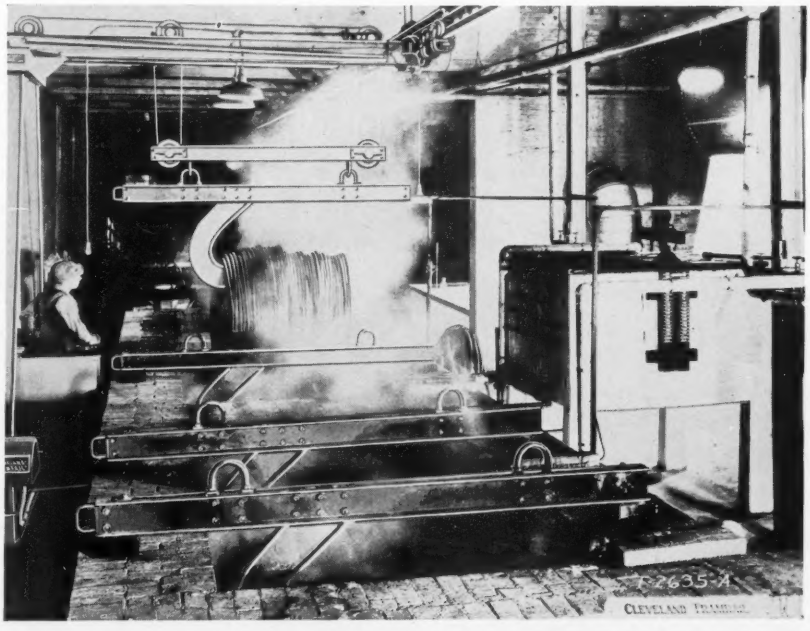

Figure 1. The measuring tank is shown to the right and in the foreground of Photo No. 1. It is of sufficient size to take care of acid requirements for two tubs and constructed of acid-resisting iron. A sight gauge is provided so the operator can keep an accurate check on acid furnished each tub, gravity feed is used from the 11,000 gallon main storage tank of the measuring tank and then direct to the tubs; the overflow bypasses the valve and leads direct to one acid tub for protection. ✦ ✦ ✦

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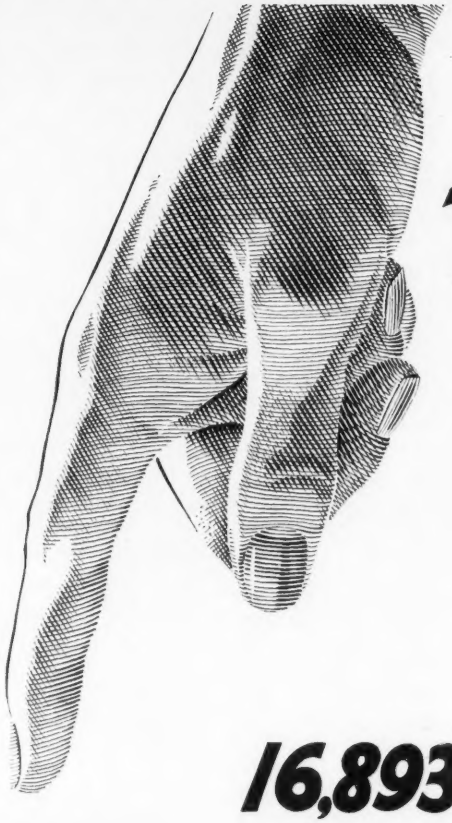

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The drain assembly is calked and sealed with jute and asphalt cement to the discharge line which is a three inch Duriron pipe leading direct to the sulphate plant for deposit and partial neutralization of the spent acid. To fully protect the floors and outside of the tanks an overflow pipe is provided eight inches from the top of each tank which leads to a receiving tank where the solution can be returned to the tub when desired rather than being a complete loss if connected to a sewer.

✦ ✦ ✦

DURIRON circulation steam jets are located in the corner and reach to the bottom of each tub and extend inward about eighteen inches. Steam of 80 to 125 pounds is used to heat the solution 160 to 190 degrees. Temperatures are accurately maintained by Foxboro temperature control instruments.

✦ ✦ ✦

IN many old cleaning houses the rinsing of rod is accomplished by swishing the pin in and out of a rinse tank and then applying a stream from a high pressure hose. In this plant this has been dispensed with by installing a rinse tank of concrete with high pressure spray nozzles placed around the inside of the tank so that as the pinfull of rod is lowered into the tank the water sprays hit the rod from several angles and do a splendid job of rinsing. Undoubtedly, some wire mill superintendents are of the opinion that this method of rinsing or spraying does not do a good job, but this installation is working satisfactorily, and in fact, the same arrangement of spray nozzles has been installed in other straight line cleaning house layouts with which I am familiar.

✦ ✦ ✦

SPRAY water is only used when rod is in the tank, and a three hundred gallon per minute capacity pump delivers water at 100 to 110 pounds pressure through five inch mains to the tank where same connects with a two inch diameter pipe on which the spray nozzles are mounted. Two lines of pipe are arranged on all sides of the rinse tank, the first line of pipe with nozzles being twelve inches from the top of the tank and the lower line twenty-four inches from the top. The pipe on each side and end of the tank is equipped with thirty-three special bronze nozzles with an opening of .085 inches thirteen degree taper, each nozzle being ¾ of an inch long and spaced 1¾ inches apart. All pipes are flush with the inside of the tank which is brick lined. This provision was made during the construction of the brick work.

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THE rinse tank is also provided with a drain pipe so that water can flow off. The operator of the gantry crane starts the motor operating the pump as he reaches the center of the rinse tank and is ready to lower the rod into the tank. The pump motor is provided with push button control at a convenient elevation so the operator does not have to step off the crane platform in order to start the flow of water, and he can duplicate the swishing and high pressure hose operation by merely lowering and raising the rod in the rinse tank. A minimum amount of rinsing water is used, as water is only forced through the spray nozzles while rinsing rod.

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THE sull rack is also of concrete with 3″ x 10″ timbers bolted to the top, to provide a cushion for the loaded hooks when lowered into place. This rack is also equipped with nozzles that give off a very fine mist and rapidly rust coat the cleaned rod. Two ¾ inch pipes run the full length with nozzles on 29 inch centers. The first pipe is nine inches from the top of the tub and the next forty-four inches. The bottom of the rack slopes ¼ inch to the foot so that sull water can drain off. This sull rack has a capacity of four pins, and no conveyor is necessary to move the loaded pins while sulling, as the crane is capable of lifting a pinfull of sulled rod and deliver it to the lime tank with time to spare. Warm air is forced into the sull tank to quicken sulling, also heat the cleaning house to keep down fumes.

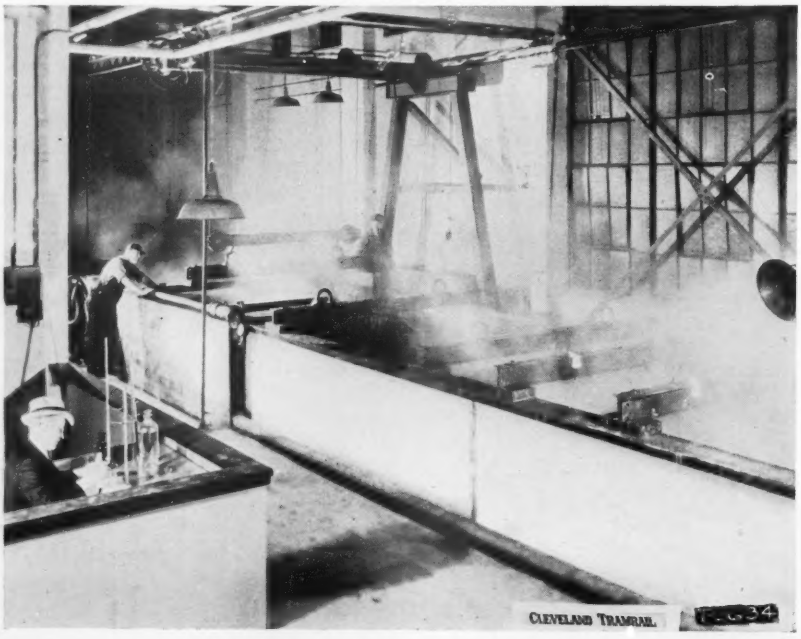

Figure 2.

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THE rinse tank, sull rack and lime tank are really one concrete shell which is set on concrete piers with a 2′-6″ clearance under the shell. This simplifies replacement of drain or sewers, and provides ample room for heating ducts. The two acid tanks are also similarly set on concrete piers.

A STEEL storage tank for acid of eleven thousand gallons capacity is erected to one side of the cleaning line shown on plan at a suitable elevation so that acid can be drained from the tank into a measuring tank, also shown in the plan. This measuring tank of concrete with brick lining has sufficient capacity to fill a two pin tank when a new solution is necessary. As the solution in the tank weakens additional acid can be discharged into the tank and the amount can be accurately measured by a sight gauge so the operator can keep an accurate check on acid furnished each tank.

✦ ✦ ✦

THE next illustration shows a photograph of this cleaning house, and your attention is called to the location of the acid storage tank and measuring tank, also the position of the operator in the cab. Your attention is called to the orderly arrangement, as well as the dry floors and note the desk and chemist's tubes.

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AS mentioned before, the actual time the gantry crane is in service during the cleaning cycle is approximately three and one-half minutes. On a longer layout for a greater output this time would remain the same as the longer distance travelled is equalized by increasing the crane traveling speed. Such installations have been made for a capacity of four hundred tons in twenty-four hours with a cleaning line 160 feet long.

✦ ✦ ✦

IT is understood, of course, that for a cleaning house with a four hundred ton capacity, the crane operator would be devoting his entire time to handling rod with the crane and an additional man would be required to move the loaded buggies from the gantry crane at each end of the layout, or a floor type power operated conveyor could be provided which would bring the rod to the front end of the line where it would be taken off the buggy with the hair pin hook, also another conveyor could be provided at the baker end of the line, but I wish to emphasize that only one operator is required for manipulating the crane for handling the rod during the actual cleaning cycle.

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AS mentioned before, materials handling equipment has played an important part also in the cleaning house, and I cannot help but remark about what is a good specification for the construction of a cleaning house crane.

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TO begin with, simplicity of construction is the most desirable. This is best obtained by the single leg gantry type of crane, as it is possible to locate all the machinery for the hoist and travel motion in the leg of the gantry also provide an operator's platform for conveniently getting on and off the crane when necessary.

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THE machinery of the crane being placed below the tank level can be enclosed with splash covers and all of the equipment, electrical and mechanical, is kept away from acid and steam vapors.

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BY placing the machinery between the gantry leg it is possible for the Maintenance Department to go over the equipment regularly in less time, repairs or replacements can be made with less effort than would be possible if such equipment were mounted above on overhead crane girders.

✦ ✦ ✦

THE only parts of the crane that are in the acid vapor zone are the cables, the upper sheave and the wheels on the end truck operating on the upper runway. The sheaves and end truck wheels are provided with pressure lubrication fittings and since anti-friction bearings are used a monthly inspection for lubrication is all that is necessary.

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YOUR attention is called to the fact that no trolley or rack motion is provided on the crane. This is not necessary when the straight line layout is made to provide for handling rod at each end of the layout. It is one reason why the crane is so simply constructed.

✦ ✦ ✦

THE crane travel motion is obtained by driving the truck wheels on the gantry leg. Each wheel is separately motored and mounting is such that easy inspection is possible. The motor drive on the wheels in the gantry leg is possible because the upper runway is flexibly suspended and en truck wheels are permitted to swivel preventing binding. This type of crane is capable of traveling at speeds up to 600 feet a minute and can be spotted and stopped with a foot brake actuated from the operator's platform and operates on the top of the runway rail set in the floor.

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THE hoist motion is simply arranged. The hoist drum is connected to the motor through a train of gears, the drum is scored for two parts of cable providing a twin hook suspension with sheave in the boom of the crane, cable running over same to a set of sheaves in the load bar provided with two hooks which engage with the eyes in the hair pin hook proper. An upper and lower limit switch is provided which cuts off the power if the operator goes beyond his reasonable operating limits.

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THE twin cable suspension for the hair pin hook prevents the load from twisting and enables the operator to place a load either in the acid, sull racks, rinse or lime tanks in the shortest possible time, and it is remarkable to note how quickly the operator becomes accustomed to engaging the hooks on the load bar of the hoist with the eyes of the hair pin hook. I have observed that some operators have become so skilled that they can actually pick up a load while the crane is in motion.

✦ ✦ ✦

IN the last few years other types of acid tanks have also been been used in cleaning houses, and I wish to mention here that rubber lines tanks with acid brick facing in the tank is also being used, and it would pay a wire mill superintendent or engineer to consider the various tank constructions which are offered by various manufacturers.

✦ ✦ ✦

OF the ten installations using the straight line layout with the single leg gantry crane with

(*Please turn to page 603*)

Endurance Tests on Electrolytic Tough Pitch and Oxygen-free Copper Wire

By J. N. Kenyon, Testing Engineer

Instructor in Civil Engineering, Columbia University, N. Y.

A synopsis of an address to be delivered at the Wire Association Meeting at Cleveland, Ohio, Thursday, October 22, 1936. This is a study of recent endurance tests on copper wire.

ENDURANCE tests on non-ferrous materials such as copper are time-consuming and considerable development work had to be done to make these tests possible. The author states that it is undesirable to publish any data unless he is absolutely sure of its accuracy, and therefore, cannot at this time authorize the publication of anything beyond the following synopsis of his paper on this subject. The study will be complete sometime early in 1937, at which time it will be published in its entirety. In the meantime, the author will present the incompleted article, accompanied by lantern slides, at the Annual Meeting of the Wire Association in order to present the information which has been developed up to date and to illustrate the technique of making the tests.

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WHILE the endurance limit of copper has been fairly well established by tests by the rotating-beam method, there appears to be little or no endurance data on copper wire. This is probably due to the lag in the development of a satisfactory test method, and to the amount of time consumed in making endurance tests on non-ferrous materials. Endurance tests on fabricated wire are important since—in the case of ferrous materials, at least—the usual commercial surface condition is, to a large extent, the controlling factor. In consideration of these facts, endurance tests on electrolytic tough pitch and oxygen free copper wire are being undertaken by the writer.

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STRAIGHT lengths of 0.080" diameter copper wire, both in the annealed and hard-drawn conditions, were selected for the investigation. This size of wire is commonly used for routine tests such as cold bends and the L & N Conductivity bridge. The tests are being made by a stress reversal method known as the Rotating-Wire Arc Fatigue Machine, a method developed by the writer and described in the 1935 A. S. T. M. Proceedings. It appears, however, that some experimental work and a modification in the Arc method must be made, before satisfactory results may be obtained on soft annealed copper wire.

JOHN NATHAN KENYON

Born at Troy, Pa. in 1886. In 1916 charge of inspection of munition steel with British War Mission. In 1918 employed by Carnegie Steel Company in manufacture of electric furnace steel. In 1923 employed at Columbia University as testing engineer and recently appointed Instructor in Civil Engineering. Degree of A. B. from Syracuse University; degrees of B. S. and MetE from Columbia University. Member of the British Institute of Metals, American Society for Testing Materials and the Electrochemical Society. Published following studies in the A.S.T.M.: "The Effect of the Addition of Lead on the Hardness of Certain Tin-Base Bearing Alloys at Elevated Temperatures." "A Rotating-Wire Arc Fatigue Machine for Testing Small Diameter Wire". "The Effect of the Addition of Lead on the Endurance Limit of a Certain Tin-Base Bearing Alloy."

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ON the hard-drawn materials, tests have already been made up to 100,000,000 stress reversals, and probably 300,000,000 reversals will be necessary before a definite endurance limit can be established. Certain tentative conclusions, however, have been reached with regard to the hard-drawn materials, but these are being presented with reservations, since the investigation is by no means complete:

(1) The Oxygen-Free material shows a somewhat higher endurance limit.

(2) The effect of the usual commercial surface condition on the endurance limit of copper wire is not so pronounced as in the case of steel wire.

✦ ✦ ✦

IN connection with these tests, a new method for determining the endurance limit of small diameter wire used in elevator and hoisting cable was developed at the Engineering School of Columbia University by the author. Heretofore a consideration of the fatigue limit of these wire materials has been to a large extent neglected because of the difficulties involved in making the fatigue tests. Wire rope specifications call for static tests (that is, tension, torsion, and cold bends) and, according to British investigators, give little indication of the true service qualities of these materials. Recent developments may lead to revision in present wire rope specifications.

✦ ✦ ✦

THE new fatigue machine is based on the mechanical principle that a rotating curved wire automatically tends to assume the form of a circular arc. Stress com-

(Please turn to page 593)

Exports and Imports of Wire

Exports of Iron and Steel Wire Products in July, 1936 and July, 1935
(In gross tons)

	July 1936	June 1936	July 1935
Wire rods	2,132	3,317	2,824
Hoops, bands and strip steel	6,052	6,002	3,627
Plain black or galvanized iron or steel wire	3,702	4,069	2,553
Barbed wire and woven wire fencing	3,367	2,187	3,905
Woven wire screen cloth	134	94	100
Wire rope	291	231	329
Insulated iron or steel wire and cable—see analysis below			
Other wire and manufactures	460	399	620
Wire nails	772	448	1,277
Tacks	31	32	29
Other nails, including staples	141	149	343
Bolts, machine screws, nuts, rivets and washers	464	493	536
Total, these 11 classifications	17,546	17,421	16,133

Imports of Iron and Steel Wire into the United States
(In gross tons)

Concrete reinforcement bars	364	501	721
Hollow bars and drill steel	141	162	102
Wire rods	1,280	1,278	937
Barbed wire	949	557	1,390
Round iron and steel wire	464	420	224
Telephone and telegraph wire	1	1	3
Flat wire and strip steel	172	274	65
Wire rope and strand	220	183	138
Other wire	124	64	187
Hoops and bands	2,777	979	3,501
Nails, tacks and staples	1,659	1,479	1,841
Bolts, nuts and rivets	57	16	28
Total, these 12 classifications	8,208	5,914	9,137

Exports of Insulated Wire and Cable July, 1936

	Foreign		To U. S. Possessions	
	Pounds	Dollars	Pounds	Dollars
Insulated iron or steel wire and cable	19,256	$ 4,438	1,789	$ 366
Rubber-covered wire	390,728	81,247	140,994	17,907
Copper weatherproof wire	201,052	27,278	85,834	13,882
Copper telephone cable	28,033	5,480	1,013	292
Other insulated copper wire	278,674	71,001	167,033	24,858
Nickel-chrome electric resistance wire	30,319	41,347	174	243
Total, these 6 classifications	948,062	$230,791	396,837	$57,548

July Iron and Steel Exports at Higher Level Than Last Year —Imports Recede

JULY iron and steel exports from the United States (excluding scrap) were at a higher level (13.8 percent in quantity and 28.2 percent in value) than in the corresponding month of 1935, a total of 98,933 gross tons valued at $7,161,426 being destined to overseas markets. When compared with the substantial trade prevailing in June, however, slight declines (1.4 percent in quantity and 1.5 percent in value) were recorded.

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PRONOUNCED gains were registered in shipments of tin plate, black steel sheets, heavy rails, 'other plate', wire rods, plain shapes, strip steel, and unlined tanks—comparing the two periods. Declines were chiefly noted in those of 'other steel bars', galvanized steel sheets, and ingots, blooms, etc.

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Import Total Lower in July

A LOWER volume of iron and steel imports (excluding scrap) was received from foreign suppliers during July—when compared with the previous month—the aggregate of 38,350 tons valued at $1,600,760 recording declines of 4.4 percent in quantity and 3.4 percent in value. Compared with the trade during July, 1935, however, respective gains of 26.4 percent and 26 percent were registered.

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Exports Continue at High Level

INCREASED shipments were registered in 33 iron and steel classifications — comparing July totals with those for June—, decreases in 29, while in one item the trade remained constant. Black steel sheet exports were sharply ahead (5,317 tons) of those in June, and represented the outstanding gain. Other increases of moment were those in 'other plate' (2,665 tons), ingots, blooms, etc. (2,533 tons), cast-iron pressure pipe and fittings (1,479 tons), and barbed wire (1,062 tons). The outstanding losses were recorded in tin plate (10,586 tons), skelp (2,598 tons), light rails (1,590 tons), heavy rails (1,313 tons), and wire rods (1,185 tons)

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Black Steel Sheets Chief Item of Export

SUPPLANTING tin plate (which has been the leading export item over a number of months) black steel sheets (excluding scrap) was the chief export item in July, its total of 16,088 tons finding numerous outlets, chief among which were Soviet Russia (5,379), Canada (3,308), the United Kingdom (1,915), Mexico (1,531), and Australia (1,377). Tin plate—the next item—also found widespread markets in a total trade of 16,010 tons. The outstanding purchasers were the Netherlands (1,801), Mexico (1,272), Brazil (1,154), Japan (1,130), and Uruguay (1,032). Next came 'other plate' (6,587 tons) going for the most part to Mozambique (1,776), Canada (1,404), Netherland India (578), 'other Portuguese Africa' (428), and the Philippine Islands (389). The bulk of the plain shape shipments (5,644 tons)—next in importance—went to Canada (4,378), and Cuba (326). Heavy rails (5,145 tons) followed and were chiefly purchased by Canada (2,376), Colombia (1,024), Cuba (967), Chile (500), the Philippine Islands (248). Hot rolled strip steel (4,748 tons) made up the next item of importance practically all going to Soviet Russia (2,824), Canada (1,247), and Mexico (542). Next was ingots and blooms, shipped to a total of 4,215 tons and going mostly to Japan (2,967), and China (1,000).

(*Please turn to page 603*)

Outstanding Personalities of the Wire Industry

Ralph F. Cohn Joins Pines Winterfront Co. of Chicago

RALPH F. COHN who has been quite active in Wire Association work and since 1926 connected with the Reynolds Wire Company of Dixon, Illinois, originally as chemist, then successively Chemical Engineer, Assistant to the President, and since June 1930, Factory Manager, has resigned from that company and entered the service of the Pines Winterfront Company of Chicago as Assistant to the President.

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MR. Cohn graduated as a chemical engineer from the University of Michigan in 1923. Upon graduation he was appointed instructor and taught Chemistry for one year while studying for a Master of Science degree which was granted in June, 1924. He is a member of the highest honorary scientific fraternity, Sigma Xi and is a member of Phi Epsilon Pi. From 1924 to 1926 did special research consulting work for the American Smelting & Refining Company and then entered the employ of the Reynolds Wire Company of Dixon, Illinois. During his connection with that company, prepared and carried out plans for rebuilding the wire mill along modern lines combining a new plant layout with changes in equipment and methods which brought the company to a point where it was recognized as one of the leaders in the technique of drawing steel wire into quality wire, particularly in the very fine sizes of wire.

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IN May, 1934 he was made secretary of the company with supervision of accounting, purchasing and development work and continued acting as Factory Manager.

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E. H. Lewis Leaves Hatfield Wire & Cable Company

E. H. LEWIS has resigned as General Manager of the Hatfield Wire & Cable Company and is moving to the Pacific Coast.

RALPH F. COHN
Assistant to the President, Pines Winterfront Company, Chicago, Illinois.

FORMERLY Mr. Lewis was Designing Engineer in charge of wire and cable engineering of the Merchandise Department of the General Electric Company. His present address is 1000 N. Harper Avenue, Hollywood, California.

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J. R. Buchanan on Union Drawn Steel Company's Metallurgical Staff

FURTHER expanding its metallurgical service in the Detroit area, Union Drawn Steel Company, Massillon, O., has announced the addition of James R. Buchanan to the field metallurgical staff of its Detroit district sales office, effective September 1, 1936.

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A GRADUATE of Michigan State, Mr. Buchanan was formerly associated with the metallurgical department of Chevrolet motor division of General Motors Corporation in Flint, Mich., where he was also active in civic affairs. He joined the metallurgical department of Union Drawn Steel Company in April, 1936 and had been located in the home office of the company until taking up his work in the Detroit district.

Sir Newton Moore Quits Presidency of Dominion Corp.

SIR Newton Moore, president of Dominion Steel and Coal Corporation, has resigned because of ill health.

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SIR Newton, officials announced, would be succeeded by **Arthur Cross** of Montreal, formerly a director and vice president. Mr. Cross joined Dominion Steel and Coal in April, 1931, as assistant to the president and treasurer.

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ANNOUNCEMENT also was made that **H. J. Kelley** of Sydney, N. S., had been elected first vice president. Mr. Kelley, appointed general manager of plant operations in 1924, will continue in that post.

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James K. Sutherland, Assistant General Superintendent, Brier Hill Works, Youngstown Sheet & Tube Co.

MR. Sutherland entered the steel business in 1905 in the electrical department of the Republic Iron & Steel Co. He joined Youngstown Sheet & Tube in 1916 as pit craneman in the blooming mill of its East Youngstown works. In 1919 he went with the Brier Hill Steel Co., as a heater in the blooming mills, later becoming roller and turn foreman.

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IN 1924, shortly after Youngstown Sheet & Tube acquired the Brier Hill company, Mr. Sutherland was made superintendent of the blooming mill at the Brier Hill plant. Three years later he was transferred to the Campbell works as superintendent of the blooming and billet mills. In 1929 he was also given charge of the skelp mill and upon completion of the continuous hot strip mill, late in 1935, he was made superintendent in addition to his other duties.

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EMIL P. KASTIEN has tendered his resignation as Purchasing Agent for the Northwestern Barb Wire Company, Sterling, Illinois. An announcement of his future plans will be made shortly.

The Wire Association -- 1936

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Superintendent, Wire Mills
Sheffield Steel Corp.,
Kansas City, Mo.

President
RALPH K. CLIFFORD
General Superintendent,
Continental Steel Corp.,
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Honorary President
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Bethlehem Steel Company,
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Vice President
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Mechanical Engineer,
Wire & Cable Section,
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H. B. Carnahan, Assistant Works Manager, Canada Wire and Cable Company, Toronto, Ontario, Canada.

E. W. Clark, Mechanical Engineer, Wire & Cable Section, General Electric Co. Schenectady, N. Y.

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W. D. Pierson, Secretary Waterbury Farrel F'dry & Machine Co., Waterbury, Conn.

R. S. Simmons, General Metallurgist, Keystone Steel & Wire Co., Peoria, Ill.

F. A. Westphal, Superintendent, Wire Mills Sheffield Steel Corp., Kansas City, Mo.

THE Wire Association is a non-profit organization of wire mill executives, superintendents and foremen. It also includes plant engineers, traffic men, credit men, salesmen, and all others engaged in the wire industry, together with manufacturers, and other interested people who have something to sell to the wire mill or some service to render for pay.

✦ ✦ ✦

THERE are separate divisions for all the separate major interests in the wire industry, steel, iron, brass, copper, alloy, and precious metals, together with divisions relating to drawing, fabricating, forming, spring making, wire cloth, wire rope, insulated wire, electric wire and cable and all other forms of wire and wire products.

FREDERICK A. WESTPHAL
Superintendent of Wire Mills, Sheffield Steel Corp., Kansas City, Mo., Vice President, The Wire Association.

RALPH K. CLIFFORD
General Supt., Continental Steel Corp.
President, The Wire Association

✦ ✦ ✦

ACTIVITIES:

ITS specific purpose is to improve production methods and afford a clearing house for ideas on management problems, technical problems, and research work in all phases of practical wire drawing and wire working, and to develop and maintain friendly relations among the members.

✦ ✦ ✦

THE Association functions along the following lines:

1. The use of the Association headquarters as a central clearing house for information and data of all kinds which may be of interest to members.
2. The exchange of ideas on processes of production including machinery, technical processes, etc.
3. The establishment and maintenance of friendly relations among the members of the association and the development of sectional and national meetings to discuss matters of mutual interest.
4. Studies of production methods and analysis of production costs.
5. Developments in the use of new materials and new applications of existing materials and by-products.
6. Research and collection of information on personnel management, including such factors as labor turnover, seasonal changes in the demand for employees, wage scales, etc.
7. Standardization and simplification as a means for the effective elimination of waste.
8. Such other subjects as may be determined upon.

E. W. CLARK
Mechanical Engineer, Wire and Cable Section, General Electric Co., Schenectady, N. Y., Vice President, The Wire Association.

All Wire Mill Men Are Invited to Attend The Wire Association 1936 Meeting and Exhibition

At Cleveland, Ohio, October 19, 20, 21, 22, 23, 1936

In Association With the National Metal Congress

Every wire mill production executive engaged in the manufacture or fabrication of wire and wire products of any kind is invited to join the Wire Association and attend these meetings. ✦ ✦ ✦ ✦ ✦ ✦

JOHN C. CALLAGHAN

Works Manager, Canada Works, Steel Co., of Canada. Chairman, Program Committee.

Born in Montreal, Quebec, December 24, 1884. Graduated, Mechanical Engineering from McGill University, Montreal, in 1908. On graduation, was employed by The Canada Screw Company, which in 1910 became part of The Steel Company of Canada, Limited. Was appointed Works Manager of Canada Works in 1923. At present serving on the Executive Committee of The Canadian Engineering Standards Association and the Executive Council of The Canadian Manufacturers' Association. Interested particularly in Industrial Relations, Welfare and Accident Prevention. Is a past Chairman of The Industrial Accident Prevention Association for the Province of Ontario. Member, The Wire Association.

In addition to a program of research papers, a splendid opportunity is offered for informal discussions. For this purpose Wire Association Headquarters in the Hotel Cleveland are open from 9 A. M. to 11 P. M. daily.

JOHN MORDICA

Supt., Rod and Wire Works, Bethlehem Steel Company, Sparrows Point, Md. Honorary President, the Wire Association.

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F. A. Westphal, Supt., Wire Mills. Sheffield Steel Corp., Kansas City, Mo.

R. S. Simmons, General Metallurgist, Keystone Steel & Wire Co., Peoria, Ill.

R. E. Brown, President, WIRE AND WIRE PRODUCTS, New York, N. Y.

RICHARD E. BROWN

Secretary, The Wire Association, Publisher, WIRE AND WIRE PRODUCTS.

Make Your Plans Now to Come and Participate in the Discussions.

For detailed information address RICHARD E. BROWN, Secretary

THE WIRE ASSOCIATION

17 East 42nd St. **New York, N. Y.**

✣ PROGRAM ✣

Monday, October 19, 1936 at Hotel Cleveland, Ohio

A. M.—Registration—"Get Together"
1 P. M.—Directors' Meeting—Program Committee Meeting
3:30 P. M.—Annual Meeting of The Wire Association

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The Technical Sessions

TUESDAY, WEDNESDAY AND THURSDAY, OCTOBER 20-21-22, 1936

(All Research Papers Are Preprinted in the October Issue of Wire and Wire Products)

THERE WILL BE A REGISTRATION FEE OF $5.00 FOR THOSE ATTENDING THESE TECHNICAL SESSIONS AND INFORMAL MEETINGS

ADMISSION WILL BE BY BADGE ONLY

To those Registering and Attending the Meetings stenographic copies of the discussions will be available at $2.50 per copy
To all others $5.00 per copy

The Following Papers Will Be Presented and Open Discussions Held On The Topics Covered

A LIST OF QUESTIONS SUBMITTED FOR DISCUSSION ON THESE AND OTHER TOPICS WILL BE DISTRIBUTED IN ADVANCE AT EACH MEETING

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TUESDAY, OCTOBER 20, 1936

Morning Session—Hotel Cleveland—9:30 A. M.
Subjects—(a) Cleaning (b) Heat Treating (c) Material Handling

Frederick A. Westphal,
Superintendent, Wire Mills, Sheffield Steel Corp., Kansas City, Mo.
Chairman of Meeting

Paper:—Cleaning Houses in the Wire Industry.

By A. F. Anjeskey, Sales Manager, Cleveland Tramrail Division, Cleveland Crane & Engrg. Co., Wickliffe, Ohio.

A discussion on cleaning houses, covering the layout of an ideal cleaning house from the standpoint of physical dimensions, type and arrangement of tubs, suggested method for storing and measuring acid, and type of materials handling equipment used, together with illustrations of the trend toward the installation of the straight line cleaning house.

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Paper:—Atmospheres and Furnaces In The Wire Industry

By H. M. Heyn, Engineer, In Charge of Heat Treating Div., Surface Combustion Corporation, Toledo, Ohio.

A paper dealing with atmospheres and furnaces in the wire industry. A recognition on the part of the wire producers of better metallurgical control and the many ramifications for exercising this control becomes apparent considering the many different analyses of steel required by the users of wire. This has necessarily called for better heat treatment.

The many advantages of the application of prepared gas atmospheres to process furnaces are apparent although each application must necessarily be decided after careful consideration is given to all of the factors entering into an intelligent determination of costs.

Controlled atmospheres necessarily do not apply only to prepared atmospheres. Automatic proportioning gas burning equipment, the carbon diffuser or atmosphere conditioner suffice for many applications. The necessity of better understanding the chemistry of prepared gas atmospheres, and the mechanics of application, become apparent when thought and study is given to the many variations that will result due to catalytic effect and other unbalancing conditions.

AFTERNOON SESSION—HOTEL CLEVELAND—2 P. M.

Subjects—(a) Springs (b) Welding Wire

R. B. Whyte, General Superintendent
The MacWhyte Company, Kenosha, Wisconsin,
Chairman of Meeting

Paper:—The Selection of Wire Spring Materials

By J. W. Rockefeller, Jr.,
Consulting Engineer, New York, N. Y.

An analysis of various metals for springs including a discussion of music wire, annealed steel, hard wire, alloys—Cr.-V. Si-MN, etc., monel metal and phosphor bronze.

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Paper:—Steel for Arc Welding Electrodes

By R. Notvest, Chief Engineer Welding Div.,
J. D. Adams Company, Indianapolis, Ind.

Mr. R. S. Simmons, General Metallurgist, Keystone Steel & Wire Company, Peoria, Illinois, has consented to assist the writer by discussing the paper from the view point of Open Hearth, Rolling Mill and Wire Mill practice.

Vital metallurgical characteristics of drawn wire to be used for arc welding electrodes. The author endeavors to show that the requirements are entirely different due to the superheating of the metal and quick freezing of the same when utilized as arc welding electrodes.

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Sound Motion Picture:—The Manufacture of Enduro Stainless Steel

Republic Steel Corp., Cleveland, Ohio.

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WEDNESDAY, OCTOBER 21, 1936

Morning Session—Hotel Cleveland—9:30 A. M.

Subject:—Research

R. S. Simmons, General Metallurgist,
Keystone Steel & Wire Co., Peoria, Illinois.
Chairman of Meeting

Paper:—Research As Applied To Manufacturing

By C. W. Meyers, Development Engineer,
American Steel & Wire Co., Cleveland, O.

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Address:—Development and Standardization of Types of Military Equipment

By Captain Frank W. Bullock,
Signal Corps., United States Army

Sound Motion Picture:—Signal Communications Within The Infantry Regiment

AFTERNOON SESSION—HOTEL CLEVELAND—2 P. M.

Subject:—Cold Working of Metal

Lewis H. Winkler, Metallurgical Engineer,
Bethlehem Steel Company, Bethlehem, Pa.
Chairman of Meeting

Paper:—Plastic Deformation In Wire Drawing

By B. L. McCarthy, Metallurgist,
Wickwire Spencer Steel Co., Buffalo, N. Y.

This paper is intended to present a picture of what occurs when metal is cold worked, and the various factors that interfere with the uniform distribution of cold working strains. While most of the specific examples relate to the drawing of steel wire, the same general principles can be applied to the non-ferrous metals and alloys from which wire may be drawn.

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EVENING—THE MAYFAIR CASINO—7:00 P. M.

Informal Dinner of the Wire Association

Ralph K. Clifford, President, The Wire Association, Toastmaster

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Award of The Wire Association Medal

By John C. Callaghan, Chairman of Program Committee

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DINNER COMMITTEE

A. R. Zapp, Manager
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Morrison Engineering Co.
Cleveland, Ohio
Chairman

R. L. Hamaker, Dist. Sales Manager
American Lime & Stone Co.
New York, N. Y.

✦ ✦ ✦

THURSDAY, OCTOBER 22, 1936

Morning Session—Hotel Cleveland—9:30 A. M.

Subjects:—(a) Testing Copper Wire (b) Power Cable (c) Power Requirements for Drawing Copper

Waldo L. Sherman, Secretary,
John Robertson Co., Inc., Brooklyn, N. Y.
Chairman of Meeting

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Paper:—Endurance Tests on Electrolytic Tough Pitch and Oxygen-Free Copper Wire

By J. N. Kenyon, Testing Engineer,
Instructor in Civil Engineering, Columbia University, N. Y.

While the endurance limit of copper has been fairly well established by tests by the rotating-beam method, there appears to be little or no endurance data on copper wire. Endurance tests on fabricated wire are important since—in the case of ferrous materials, at least—the usual commercial surface condition is, to a large extent, the controlling factor. In consideration of these facts, endurance tests on electrolytic tough pitch and oxygen free copper wire are being undertaken by the writer.

Straight lengths of 0.080″ diameter copper wire, both in the annealed and hard-drawn conditions, were selected for the investigation. The tests are being made by a stress reversal method known as the Rotating-Wire Arc Fatigue Machine. It appears, however, that some experimental work and a modification in the Arc method must be made, before satisfactory results may be obtained on soft annealed copper wire.

On the hard-drawn materials, tests have already been made up to 100,000,000 stress reversals, and probably 300,000,000 reversals will be necessary before a definite endurance limit can be established. Certain tentative conclusions, however, have been reached with regard to the hard-drawn materials:

(1) The Oxygen-Free material shows a somewhat higher endurance limit.

(2) The effect of the usual commercial surface condition on the endurance limit of copper wire is not so pronounced as in the case of steel wire.

THURSDAY, OCTOBER 22, 1936
Morning Session (Continued)

Paper:—Vacuum Lead Sheath As Applied To Power Cable

By R. W. Atkinson, Research Laboratory,
General Cable Corp., Perth Amboy, N. J.

Three or four years ago the industry realized that while cable insulation had been improved to such an extent that failures due to defects in the dielectric had been practically eliminated, the number of failures attributed to sheath troubles were actually increasing. As a result, widespread attention was directed on lead sheath to determine the nature of these failures and to discover means of eliminating them.

Metallurgical studies showed that the sheath did not have the homogeneous structure that had been fondly imagined but had very definite regions of weakness. The persistence of these non-homogenities was found to be largely a result of the presence of finely divided non-metallic inclusions (principally oxides, remnants of lubricating materials, or gas bubbles). Various methods of eliminating this condition were tried out or suggested. More careful skimming and better Foundry practice gave considerable improvement. The use of inert or reducing gas over the surface of the lead resulted in a marked reduction in the amount of oxide; and elimination of excessive lubrication reduced the troubles from this source.

With all these improvements, however, there continued to be a section of each charge length which contained more or less prominent flow lines when properly etched and showed mechanical weakness under certain test conditions. It occurred to us that the only complete solution was to keep the lead from contact not merely with oxygen but with any gas at all times after leaving the melting kettle. This has been accomplished by maintaining a high vacuum in the press cylinder and in the feed line to the press. At the same time the lubrication of the ram and cylinder walls between charges was of necessity eliminated. This method of Extrusion (termed the "vacuum" process) has made possible the complete freedom of pure lead sheath from all visible flow lines and from the regions of lower strength under the bending test characteristic of non-vacuum sheath.

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Paper:—Power for Cascade Drawing of Copper

By Paul M. Mueller, Mechanical Engineer,
Rome Division, Revere Copper & Brass, Inc., Rome, N. Y.

In answer to criticism that the published data on the drawing of wire is entirely theoretical or at least so involved that its practical application is lost, the author presents data covering the ranges of breakdown in intermediate drawing from which it is simple to calculate a given series of drafts for the various types of drawing equipment in general use.

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Motion Picture:—The Tactical Employment Of The Anti-Aircraft Artillery Regiment

A sound motion picture illustrating the use of anti-aircraft artillery and communication methods.

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AFTERNOON SESSION—HOTEL CLEVELAND—2 P. M.

Subject:—Dies and Tools

Kenneth B. Lewis,
Consulting Wire Mill Engineer, Worcester, Mass.
Chairman of Meeting

Paper:—Tungsten Carbide and Its Application to Dies and Tools

By A. R. Zapp, Manager, Firthaloy Division,
Firth Sterling Steel Corp., McKeesport, Pa.

A study of the metallurgical characteristics of tungsten carbide and its application to dies and tools.

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Paper:—A Method of Handling Tungsten Carbide Dies Within The Die Room

By K. R. Beardslee, General Sales Manager,
Carboloy Company, Inc., Detroit, Mich.

This paper covers a suggested method of servicing tungsten carbide dies within the die room, outlining economies to be effected through proper handling and efficient service methods.

Wire Association Membership List—1936

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BUSH, MAJOR GEORGE P.,
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Office of Chief Signal Officer,
Washington, D. C.

BYRON, RALPH, Manager,
Heater & Oven Department,
J. O. Ross Engineering Corp.,
New York, N. Y.

CALLAGHAN, JOHN C., Works Manager,
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Steel Company of Canada, Ltd.,
Hamilton, Ontario, Canada.

CARNAHAN, H. B., Assistant Works Manager,
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Toronto, Ontario, Canada.

CARROLL, JAMES J., President,
Steelcraft Piston Ring Co.,
Detroit, Michigan.

CASEY, AUSTIN, Sales Engineer,
Syncro Machine Co.,
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CASSIDY, LEVI M.,
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Balloffet Diamond Wire Dies Co., Inc.,
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(*Continued on Page 586*)

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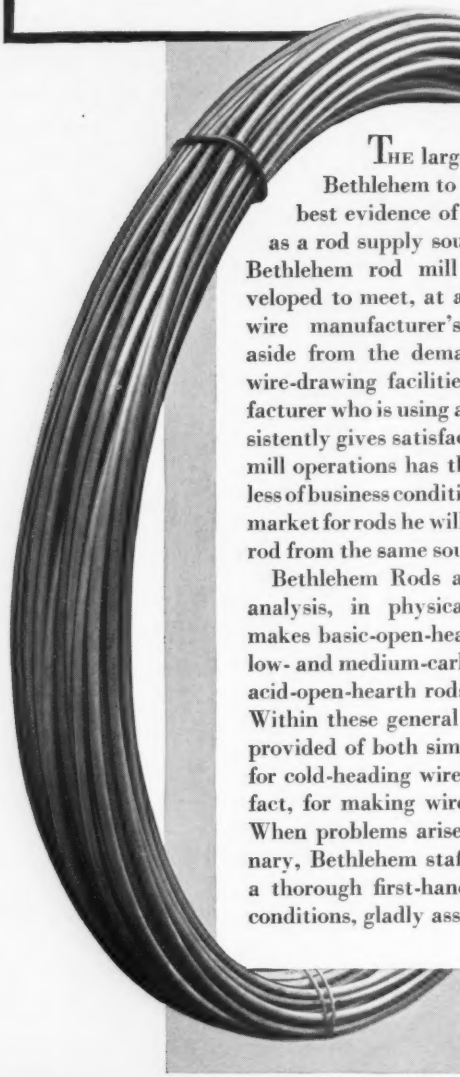

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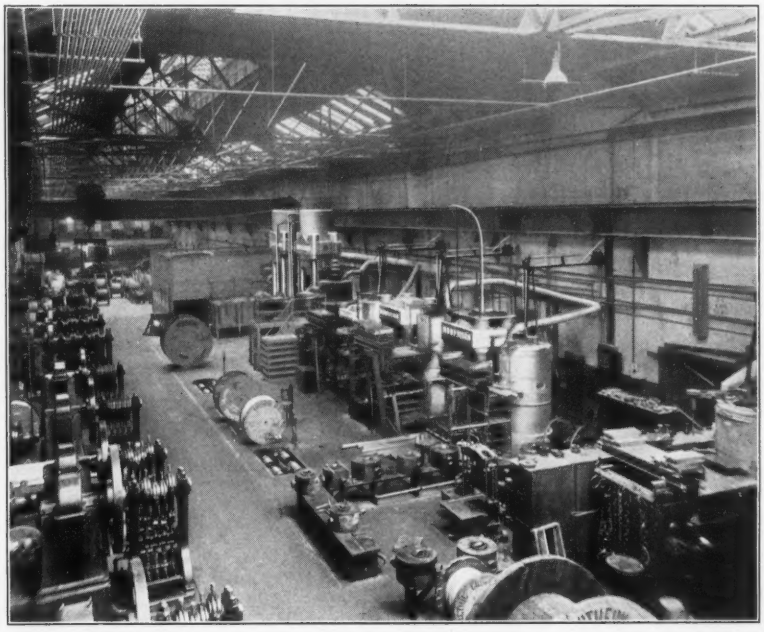

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(*Continued on Page 590*)

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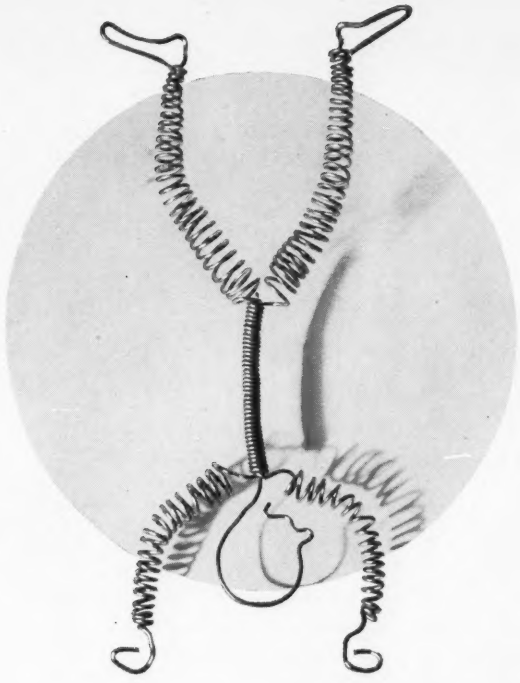

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1. The cooperative, confidential services of the Association through which members exchange ideas without identities being revealed and endeavor to help each other in plant management and process problems.
2. Participation in all Meetings of the Society.
3. A copy of the ANNUAL WIRE BUYERS' GUIDE AND YEAR BOOK OF THE WIRE ASSOCIATION.
4. A subscription for one year to the designated official publication of the society, WIRE AND WIRE PRODUCTS.

For detailed information address

Richard E. Brown, Secretary

17 East 42nd St. New York, N. Y.

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The wire industry sorely needs brains in the Treasury Department and the Department of Commerce in Washington, D. C. . . . We must stop the importation of wire products from cheap labor markets in Europe . . . Vote the Republican ticket.

THE WILLIAM M. PARKIN CO.

Chemical Engineers to the Steel Industry

HIGHLAND BLDG., PITTSBURGH, PA.

— 1860 —

The Selection of Wire Spring Materials

(*Continued from page 526*)

pears to possess better corrosion resistant properties.

✦ ✦ ✦

Nickel Silver

COMPOSITION 55% Copper, 27% Zinc, 18% Nickel, is used in some special cases of spring manufacture where a corrosion resistant white metal is desired. Its ultimate strength is in the neighborhood of 100,000 lbs. per sq. in. and its elastic limit about 55,000 lbs. per sq. in. Unlike many of the other non-ferrous spring materials it is not a good conductor of electricity and is therefor not suitable for most electrical instrument applications.

✦ ✦ ✦

Beryllium Copper

COMPOSITION 97.75% copper, 2.25% beryllium, is one of the most recently developed spring materials. It has a very high coefficient of electrical conductivity and in the short time it has been used has indicated very promising possibilities as a material for use under corrosion-fatigue conditions. This material is cold drawn to size, coiled and given a subsequent heat treatment at low temperatures. Samples of this material, after such treatment have shown an ultimate strength of over 200,000 lbs. per sq. in. and have withstood over five million stress cycles between 50,000 lbs. per sq. in. and 70,000 lbs. per sq. in., in finished spring form.

✦ ✦ ✦

THE choice of a spring material depends upon other factors than those having to do with the physical properties of the finished spring. As mentioned above, cost is frequently a factor to be considered. The ease with which a material may be handled is frequently important. Spring wire with a highly polished surface is likely to slip in the rollers of a coiling machine when springs of very small diameter are being coiled, resulting in non-uniformity of length and number of coils in the finished spring. When such a condition is encountered, it is necessary to manufacture the springs in a continuous coil, cutting them to length by hand after coiling. A wire of equal physical properties, but possessing a duller finish in some cases will permit the coiling and cutting both to be accomplished in one operation on a single machine, thus effecting a saving in manufacturing costs.

✦ ✦ ✦

THE process by which a wire has been manufactured will indicate to some degree what may be expected of it during the coiling operation. As a general rule, cold drawn wires which have been strengthened by drastic reduction in diameter between successive drawing operations may not be expected to coil as uniformly as wire which has been subjected to light and slow draftings.

✦ ✦ ✦

THE composition of wire also has a bearing upon such subsequent operations as the plating of springs, it having been found,

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✦ ✦ ✦

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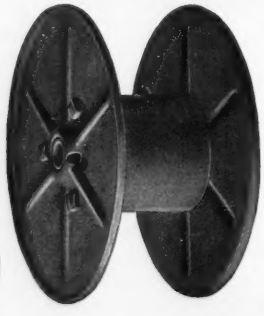


STRANDING REELS BRAIDER REELS VULCANIZING REELS

at least in the experience of some spring manufacturers, that alloy steel wires exhibited less tendency toward embrittlement than straight carbon steels during this process.

✦ ✦ ✦

IT should be borne in mind that the manufacture of springs is far from being universally standardized and that conditions under which springs operate are anything but uniform. For this reason it is extremely risky business to attempt to draw general conclusions from specific cases. There can be as much difference between the physical properties of springs made of straight carbon wire of the same analysis obtained from different sources as between straight carbon steel and alloy steels. It would be a rather difficult task to find two spring makers who would be in complete agreement upon the relative merits on all materials that have ever been used in the manufacture of wire springs. In an article of this length, it is impossible to deal exhaustively with the properties of all wire spring materials. Some useful materials which have a very limited field of application have been purposely omitted. The list is set forth as a guide for the user and manufacturer of springs, but there can not be any more hard and fast rules for the selection of a spring material than for spring design. Each case presents its individual requirements and in order that these requirements may best be satisfied, it is necessary that the user of the spring, the manufacturer and the wire mill that furnishes the material all have a very sound comprehension of the nature of the requirements.

✦ ✦ ✦

Endurance Tests on Electrolytic Tough Pitch and Oxygen-Free Copper Wire

(*Continued from page 576*)

putations are therefore very simple. The wire test specimen rotates at high speed and subjects the fibers of the outer curvature to a tension stress and the fibers of the inner curvature to a compression stress. When a fatigue crack once starts on the surface, it is rapidly opened and closed until the wire breaks. The wire specimen is rotated in an oil bath to dampen vibration.

✦ ✦ ✦

THE machine is now being used to test wire of .024 to .050 of an inch in diameter used in typical wire rope fabrication. The test method may be used for much smaller wire and has theoretical application to lamp filaments.

THERE WILL BE A REGISTRATION FEE OF $5.00 FOR THOSE ATTENDING THE WIRE ASSOCIATION TECHNICAL SESSIONS AND INFORMAL MEETINGS ADMISSION WILL BE BY BADGE ONLY

✦ ✦ ✦

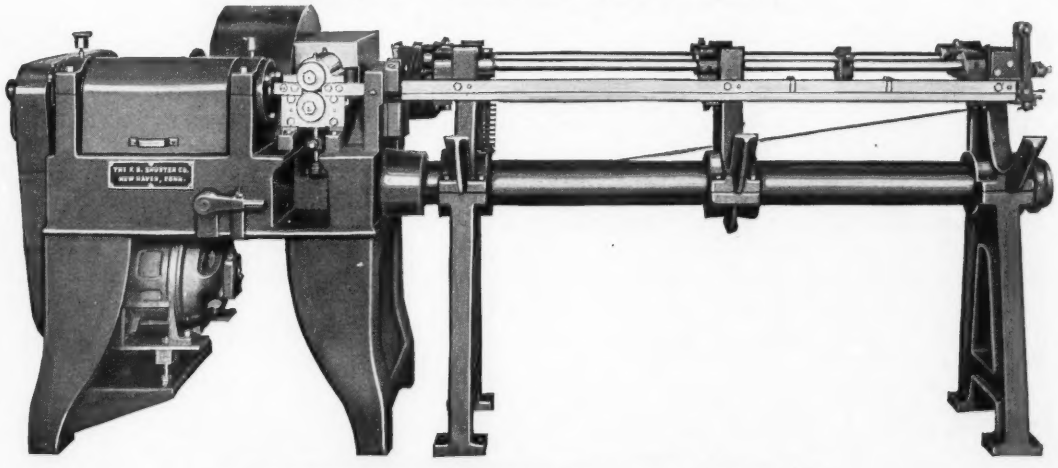
To Those Registering and Attending the Meetings, stenographic copies of the discussions will be availiable at $2.50 per copy.

To all others $5.00 per copy.

SHUSTER "HIGH SPEED"

AUTOMATIC WIRE STRAIGHTENING AND CUTTING MACHINES

REDUCE YOUR LABOR COSTS



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'Round the World With the Wire Industry

Changes in Iron and Steel Policy of Japanese Government

IT has been mentioned that the **Japanese** Government was considering the granting of permits to independent steel makers for the erection of smelting furnaces, thus indicating a change in the Government's policy. Trade Commissioner Paul P. Steintorf, Tokyo, now writes that this has been definitely confirmed by more recent developments and that it is now certain that the Government has definitely abandoned its plan to organize the entire industry into a single company built around the present Japan Steel Company (Nippon Seitetsu) which was organized in 1934 by a merger of Government plants and five independents. It is stated that the present Government plans to follow a more positive policy in order to eliminate the present dependence upon foreign sources for pig iron and steel scrap. To this end, both the Japan Steel and the independent companies will smelt their own ores whereas at present, Japan Steel is the only producer of pig iron, the other companies purchasing their pig and scrap.

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✦ ✦ ✦

Japan Steel Considers Erection of Strip Steel Mill

CONSIDERATION by the above-named **Japanese** firm to the erection of a continuous strip steel mill in order to increase its production of specific steel, tin-plate and hoop steel is reported by Trade Commissioner Paul P. Steintorf, Tokyo. The cost is estimated between 15 million and 20 million yen. It is held possible that the necessary equipment may be purchased in the United States.

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Japanese Hoop and Band Market

JAPANESE producers increased their quotations materially for hoops and "ribbons" owing to the higher import duties effective June 1, advises Trade Commissioner Paul P. Steintorf, Tokyo. It is now reported, however, that the International Hoop Steel Syndicate has lowered prices for the Japanese market to such an extent that they can undersell the domestic producers, despite the higher duties. In consequence, the market has become somewhat upset and domestic producers are agitating for the imposition of dumping penalties against the syndicate.

✦ ✦ ✦

German Notes

GERMANY, now a large exporter of wire and wire products was able to increase exports with a few exceptions so far this year. Compared with the first half of 1935, Germany's exports in 1936 were as follows: Bright wire, 33,-

'Round the World With the Wire Industry

550 tons in 1936, 34,918 tons in 1935; Brazil, the Netherlands, Turkey, and Russia were the best customers. United States took only 474 tons as compared with 621 tons last year. Exports of finished wires, (tinned, galvanized, coppered, annealed, etc.) were 40,144 tons in 1936, 32,554 tons in 1935, being exported mainly to the Netherlands, Brazil, Norway, South Africa and Great Britain. United States imported 696 tons compared with 486 tons last year. Exports of wire ropes and strand wire rose from 5,830 tons to 8,059 tons this year. Italy was the best customer, followed by the United States with 862 tons as compared with 527 tons last year, and India third with 685 tons. Exports to Overseas rose more rapidly than to Europe.

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BARBED wire exports were lower due to reduced purchases by the United States. Total exports were only 23,711 tons compared to 11,714 tons last year, but it is reported that during July and August, American purchases have increased. Brazil took 6,074 tons in 1936, 8,291 tons in 1935. Exports of wire netting and wire mesh amounted to 7,057 tons as compared to 6,320 tons in 1935, of which 1,169 tons were absorbed by South Africa and 449 tons by the United States. Wire nail exports rose to 16,943 tons compared to 14,724 tons in 1935 of which the United States absorbed 10,798 tons. The United States has thus absorbed nearly two-thirds of total German wire nail exports. Exports of small wire work products (wire brushes, wire cages, spring wire products, etc.) were 3,447 for 1936 as compared with 2,824 tons in 1935, of which the United States took only 98 tons.

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FUTURE export trade looks satisfactory because during July and August orders for nearly all products were increasing. A further improvement is anticipated for the early autumn months when the Asiatic markets continue to buy.

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FOR the Olympic games, 28 tons of barbed wire, 102 tons of mesh and netting, 14 tons of fencing wire, 28 tons of signal wire, 114 tons of nails and 81 tons of other wire products had been directly or indirectly ordered by the Committee and were used for various purposes.

THE wire rod export business is at a lull. Only China has recently ordered more, all other markets are buying slowly. The price is unaltered at L (Gold) 4.10.

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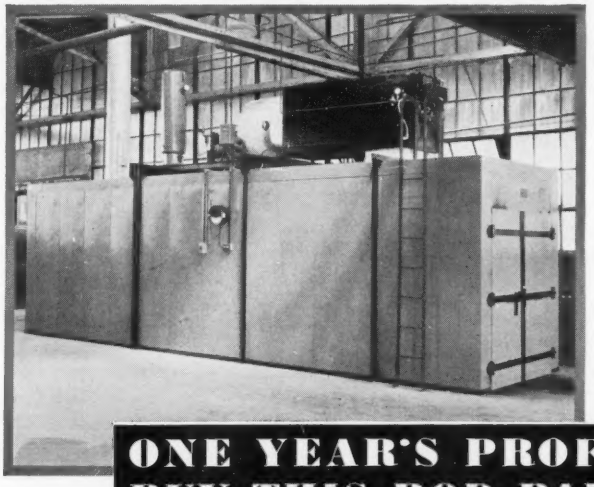
RUSSIA has been buying a lot of used wire machines. German wire producers return old machines to the maker in part payment for

(*Please turn to page 596*)



ONE YEAR'S PROFITS BUY THIS ROD BAKER

This is a strong statement! There is a lot to back it up. Many a Morrison rod baker has doubled production with the same or less fuel consumption. Some have done even better. There's no miracle to it—just sound design based on exclusive Morrison features that actually produce results. Savings go on after the rod has cooled off. Every inch is perfectly uniform—no rust—no squeaks. Yes, Morrison rod baking equipment can often return its cost from profits of the first year's operation.

Other Morrison equipment is designed for annealing, heat-treating, and galvanizing; tank and pot heating; and other industrial process heating applications utilizing the recirculating forced convection method.

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Morrison Engineering Company, Inc.

5005 EUCLID AVE. CLEVELAND, OHIO

'Round the World With the Wire Industry

(*Continued from page 595*)

new machines, and the maker exports the machines, modernized and repaired, to Russia.

✦ ✦ ✦

THE IWECO, which was recently extended up to end of 1940, has decided to leave prices unaltered for all markets for the next 2 months and only in certain Asiatic markets, where Japanese competition is keen, fluctuating quotations have been issued. The Japanese inland wire prices have been raised by 4 to 6% and quotations to Manchukuo are also slightly higher.

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ROD MAKING MACHINES

make from the hot-rolled or extruded coil material, in continuous operation and with one operator:

PERFECTLY STRAIGHT AND HIGHLY POLISHED RODS

also squares, hexagons, flats.

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straighten and highly polish:

ROUND RODS
TURNED OR GROUND SHAFTING
GROUND DRILL RODS

etc.

✦ ✦ ✦

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Phillips Electrical Works at Brockville Extending Facilities

J. B. McCARTHY, vice president of the Phillips Electrical Works, announces that plans and specifications have been drawn up for the construction of two additional buildings at the Brockville plant. Construction work will be started at an early date, and it is anticipated that both structures will be completed and ready for occupancy by the first of November. The new buildings will involve an expenditure of approximately $200,000.

✦ ✦ ✦

Niagara Wire Weaving to Erect Addition to Plant in Ontario

VOTERS of Niagara Falls, Ontario have approved a plan for a fixed assessment of $110,000 for ten years on property of the Niagara Wire Weaving Company, thereby assuring construction of a large addition to the company's plant here. Increased output is planned following the opening of the new unit.

✦ ✦ ✦

Vaughn Awarded Big British Order

THE **Vaughn Machinery Company** of Cuyahoga Falls, Ohio, were recently awarded a large order covering complete wire mill equipment for the new Cardiff, South Wales plant of Guest, Keen and Nettlefolds, Ltd., Birmingham, England—one of the largest manufacturers of steel and allied products in Great Britain.

✦ ✦ ✦

THE complete plant will be ready on or about January 1st, 1937, and will have an annual capacity of approximately 50,000 tons of wire in sizes down to No. 20.

✦ ✦ ✦

THE combination equipment embraces wire-drawing machines of various types including the well-known MOTOBLOC and MOTOBLOX for single and continuous drawing.

VAUGHN MACHINERY'S order is part of an extensive new building and modernization program on the part of Guest, Keen and Nettlefolds, it is reported. Transfer has been made of the English company's wire-drawing plant and nail works from Newport and Rogerstone to Cardiff, where steel-making activities are to be concentrated, with new coke ovens, blast furnaces, steel melting and rolling plants having a weekly capacity of 6,000 tons coke, 9,000 tons pig-iron, 7,500 tons ingot and 6,500 tons of finished rolled steel.

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IMPROVED business conditions are said to be also reflected by increased activity in Guest, Keen and Nettlefolds' works in Australia, Canada, South Africa and Buenos Aires. The Company is also closely connected with John Lysaght, Ltd., who are the largest shareholders in Guest, Keen and Baldwins' Iron and Steel Company, Ltd.

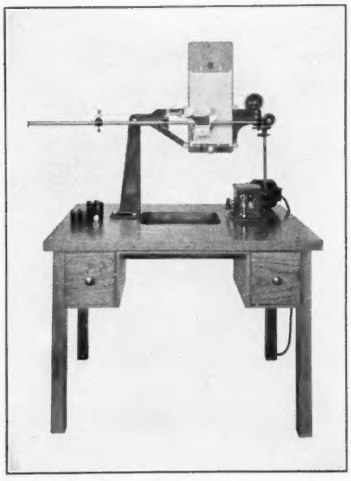
✦ ✦ ✦

German Syndicate for Wire and Wire Products Will Apparently Be Extended

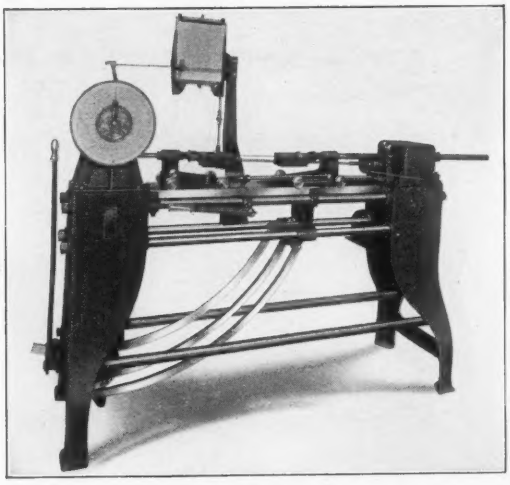
GERMAN manufacturers of wire and wire products hold the opinion that the prolongation of the International Wire Export Corporation which is to be effected for another five years, beginning 1937, depends largely on the extension of the German syndicates which are also due to terminate at the end of the current year, reports Consul General A. W. Klieforth, Cologne. While it is believed that this extension will be effected, there are plans under consideration tending towards the amalgamation of two principal syndicates, that is, the Drahtverband Dusseldorf and the Hagener Vereinigung der freien Drahtworks und Drahtstiftefabriken. The two afore-mentioned organizations are also the subject of negotiations for extension beginning the year 1937. The wire rope syndicate will not

(*Please turn to page 605*)

SCOTT TESTERS



Model IP-2
Maximum capacity
2 pounds



Model Q-5
Maximum capacity
2000 pounds

AUTOGRAPHIC recording tensile testing machines built on either the constant specimen rate of load or constant speed of pull principles. Made in a wide range of models and capacities with high and low stretch magnification recorders - for Wire, Sheet, Metals, Rubber, Textiles, Paper, etc.

May we have your specifications?

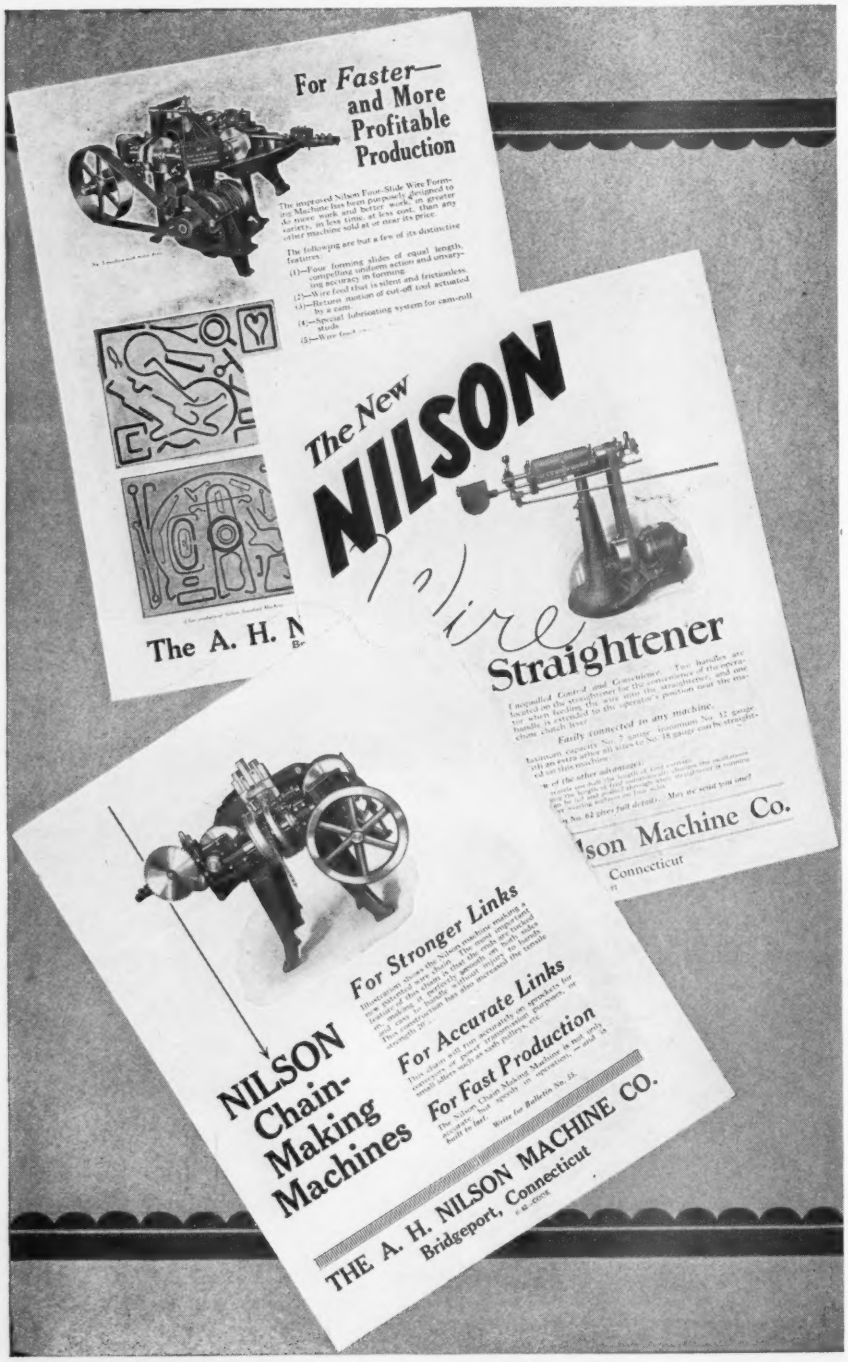
HENRY L. SCOTT CO.

P. O. BOX 963 PROVIDENCE, R. I.

Miniature Steel Plant for Research And Development Work

A MINIATURE steel works for developing the discoveries of its research engineers will be constructed by the **Jones & Laughlin Steel Corporation,** it was announced recently. One of the first of its kind in the country, the midget plant will be equipped with actual steel-making units on a small scale capable of duplicating the operations in the big mills necessary to manufacture of iron and steel.

✦ ✦ ✦

THE construction of this miniature steel works marks a new approach to the use of research by industry, bringing it into a position of greater and more practical importance than ever before. In the past, it has been the general practice to turn over the discoveries of research engineers to the regular manufacturing departments for testing and development. Under this new system Jones & Laughlin engineers will develop and test their ideas in the new "pilot plant" where they will have entire control of the miniature steel-making equipment which will include an iron cupola, an open-hearth furnace, a Bessemer converter, a blooming mill, and various finishing devices.

✦ ✦ ✦

IN the pilot plant scientists will be able to start with the raw material, take it step by step through the blooming, rolling, shaping, and finishing operations and turn out steel products on which they will have a complete and accurate history. The engineers can thus thoroughly test their ideas under a variety of operating conditions not possible in the regular manufacturing departments.

✦ ✦ ✦

THIS forward step will enable the manufacturer to anticipate the demands of its customers for improved steels to meet new requirements in their operating procedure. Also it will give the company research engineers further opportunity to assist in developing wider markets for steel products.

✦ ✦ ✦

IN addition to housing the "pilot plant", the present research staff and equipment will be transferred to the new building which will be constructed along Longworth Street in the Hazelwood District.

✦ ✦ ✦

WITH the transfer of present research equipment and the purchase of additional machines, the research department in the new building will include practically all the facilities known to science for testing and examining steel, making this department one of the most complete in the country. An enlarged staff of trained scientists and technicians will conduct the experiments. The new project is expected to be in operation by the end of the year.

Firth-Sterling Open Dayton, O. Office and Warehouse

THE **Firth Sterling Steel Company** announces the opening of a new branch office and warehouse at 415 West Fifth Street, Dayton, Ohio, under the management of **George W. Frick, Jr.,** who will have associated with him **W. A. Nungester** and **Malcolm Forward** on High Speed, Tool Steels and Stainless Steels; **David M. Smith** and **Earl V. Johnson** on Firthite Sintered Carbides; and **Paul E. Dimling** on Firthaloy Dies.

✦ ✦ ✦

THIS warehouse will carry complete stock of Tool and Die Steels in standard sizes as well as a stock of Firthaloy Dies. They announce that as a preliminary stock, they now have the following grades in this warehouse.

Circle C—Cobalt Super High Speed Steel—Bits and Bars
Blue Chip—High Speed Steel—Round, Square and Flat Bars, Toolholder Bits, Drill Rods and Billets
Cromovan—Triple Die Steel—Round, Square and Flat Bars for High Production Dies. Billets for Forgings
Invaro—Oil Hardening Die Steel—Round, Square and Flat Bars for Dies. Billets for Forgings
Carbon Tool Steel—Round, Square and Flat Bars, Drill Rods and Billets.

✦ ✦ ✦

Houghton Exhibit at the National Metal Exposition

A YEAR of progress in the development of products and processes for the metal industry will be depicted by E. F. Houghton & Co., at its exhibit at the National Metal Exposition in Cleveland.

✦ ✦ ✦

FURTHER improvement in pickling inhibitors will be graphically displayed together with charts showing efficiency of Houghton's Pickling Inhibitors over extended periods of time.

✦ ✦ ✦

PERLITON liquid Carburizer will also be featured, and a wide range of Perlitonized samples will be on display.

✦ ✦ ✦

NEW drawing compounds which have enabled automotive and other manufacturers to increase greatly the efficiency of their drawing and stamping, will be shown, together with samples of work done by the aid of these materials.

✦ ✦ ✦

AN improved series of metal cleaners combining features heretofore not found in the average alkali cleaner on the market, will be announced at this exposition.

✦ ✦ ✦

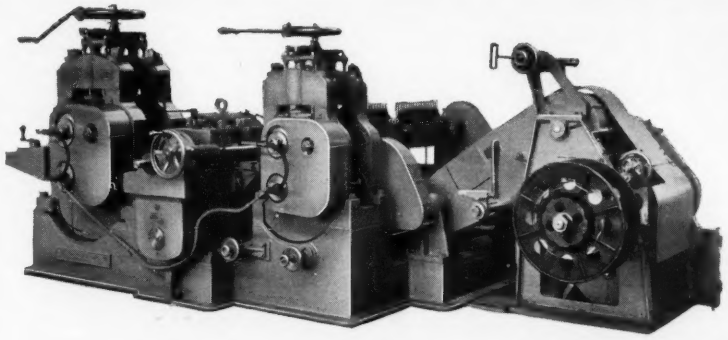
RECENT developments in cutting oil which combine the necessary features of refrigeration, film strength and lubrication will be graphically presented.

NEW wire drawing agents will likewise be shown, with proof of their efficiency.

✦ ✦ ✦

INDUSTRIAL lubricants will be included in the exhibit as well as leather belting, leather packings and Soluble Quenching Oil.

MAKE YOUR PLANS NOW TO COME TO THE WIRE ASSOCIATION MEETING



#1502 Tandem Rolling & Edging Mill With #1524 Universal Traverse Winder

USED FOR THE ACCURATE ROLLING AND EDGING OF FLAT WIRE WITH ANY EDGE CONTOUR. BREAKDOWN, EDGING AND FINISHING ROLLS, AS WELL AS WINDER, ARE EQUIPPED WITH FRICTION CLUTCHES ADJUSTABLE WHILE RUNNING TO SUIT ELONGATION AND APPLY DESIRED TENSION.

A COMPLETE SERIES OF TANDEM MILLS FULLY EQUIPPED WITH PRECISION ANTI-FRICTION BEARINGS FOR ACCURATE PRODUCT.

THE TORRINGTON MFG. CO.
INCORPORATED 1885
TORRINGTON, CONN. U. S. A.

A Review of Recent Wire Patents

No. 2,049,550, CUSHION CONSTRUCTION, Patented August 4, 1936 by William C. Van Dresser and Wesley B. Van Dresser, Detroit, Mich., assignors to Van Dresser Specialty Corporation, Detroit, Mich., a corporation of Michigan.

The construction of this cushion is such that the firmness may be adjusted for persons of different weights, the inventor employing two sizes of helical springs.

✦ ✦ ✦

No. 2,049,551, CUSHION CONSTRUCTION, Patented August 4, 1936 by William C. Van Dresser, Detroit, Mich., assignor to Van Dresser Specialty Corporation, Detroit, Mich., a corporation of Michigan.

In this form of cushion, the object being the same as the above, the inventor employs three sizes of helical springs, including several relatively large helicals.

✦ ✦ ✦

No. 2,049,575, SEAM FOR WOVEN WIRE FABRIC AND METHOD OF MAKING SAME, Patented August 4, 1936 by Walter C. Sutton, Shaker Heights, Ohio, assignor to The Lindsay Wire Weaving Company, Cleveland, Ohio, a corporation of Ohio.

The fabric is such as employed in Fourdrinier paper making machines, the construction of the wire seam being such that the ends of the fabric may be formed by metal (such as solder) without endangering the material of the wire fabric.

Complete Descriptions and Drawings of Patents May Be Had for 25 cents. Address, Wire & Wire Products, 17 East 42nd St., New York.

✦ ✦ ✦

No. 2,049,587, METHOD AND APPARATUS FOR MAKING COILS, Patented August 4, 1936 by Paul W. Lehman, Grosse Pointe Park, and George F. Wikle, Detroit, Mich., assignors to United States Rubber Company, New York, N. Y., a corporation of N. J.

More specifically, the apparatus is adapted for forming the bead portions of rubber tires by coating wire with a layer of tacky, unvulcanized material and then winding the wire into an annulus.

✦ ✦ ✦

No. 2,049,752, WELDING JOINT FOR WIRE CLOTH, Patented August 4, 1936 by Ferdinand Steinhart, Munich, Germany.

It is stated that at the welded joint of this wire cloth, adapted for use in paper making machines, the welded joint will be the same size mesh as other portions of the wire cloth.

No. 2,049,914, WIRE FEED, Patented August 4, 1936 by Arthur J. Lewis, Stratford, Conn., assignor to The Baird Machine Company, Bridgeport, Conn., a corporation of Connecticut.

The wire feed is adapted for use with wire forming machines, particularly for feeding short lengths of wire.

✦ ✦ ✦

No. 2,049,961, SPRING-STRUCTURE, Patented August 4, 1936 by Solomon Karpen, Chicago, Ill., assignor to S. Karpen & Bros., Chicago, Ill., a corporation of West Va.

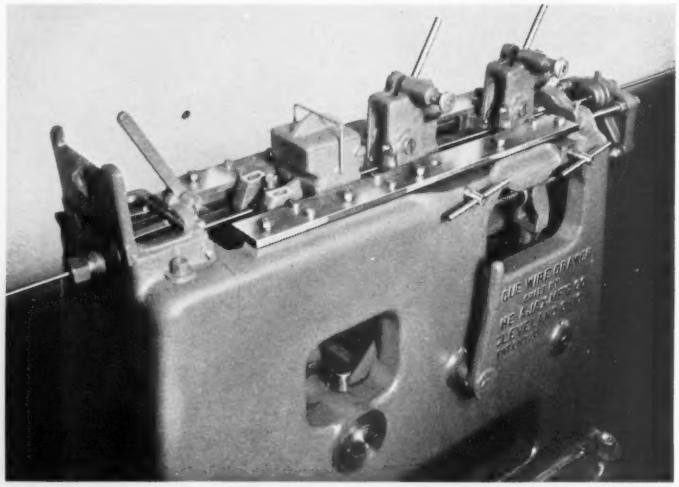
In the construction of mattresses, employing helical springs, the inventor has provided a structure which is flexible and may be rolled without producing distortion or bending of the end rings and their connections.

✦ ✦ ✦

No. 2,050,086, HIGH FREQUENCY LINE CONDUCTOR, Patented August 4, 1936 by Joseph F. Cook, Jr., West Roxbury, Mass., assignor, by mesne assignments, to General Electric Company, Schenectady, N. Y., a corporation of N. Y.

More specifically, the inventor has provided a flexible, aperiodic high-frequency cable for radio transmission lines of centralized radio installations.

CAP SCREW PLANT SAVES $3,245.00 IN FIVE MONTHS



NO. 1 AJAX-HOGUE WIRE DRAWER MANUFACTURED BY AJAX

This manufacturer operates three Ajax-Hogue Wire Drawers in combination with cold headers on ⅜" and smaller short length sizes of stock. The savings reported are the actual invoice differences between the cost of cold-drawn wire and the lower cost of using hot-rolled, pickled and limed rods. Added to this are the advantages of increased die life, reduced inventory and improved product.

It will pay you to investigate the profit possibilities of this machine in your plant. Write for Bulletin No. 111 today for more complete details.

THE AJAX MANUFACTURING COMPANY

CLEVELAND, OHIO

621 MARQUETTE BLDG.
CHICAGO, ILL.

DEWART BLDG.
NEW LONDON, CONN.

A Review of Recent Wire Patents

No. 2,050,105, SPRING CUSHION, Patented August 4, 1936 by William Lewis, Utica, N. Y.

Means is provided for tying contiguous overlapping helixes of the wire springs together to hold them against relative lateral displacement.

✦ ✦ ✦

No. 2,050,564, WIRE ROPE, Patented August 11, 1936 by Milo C. Dodge, Auburn, N. Y., assignor to Columbian Rope Company, Auburn, N. Y., a corporation of N. Y.

For the center of the wire rope, the inventor employs cellophane, claiming that this material does not absorb moisture, as does the paper cores frequently employed in wire ropes.

✦ ✦ ✦

No. 2.050,832, MACHINE FOR MAKING RETICULATED WIRE STRUCTURES, Patented August 11, 1936 by Chester E. Edwards, East Grand Rapids, Mich., assignor to Lamar Pipe and Tile Company, Grand Rapids, Mich., a corporation of Mich.

The machine is adapted for manufacturing wire cages, or metallic reinforcements to be employed in the construction of reinforced concrete columns, pipes, etc.

No. 2,050,990, CABLE, Patented August 11, 1936, by Ralph W. Atkinson, Perth Amboy, N. J., assignor to General Cable Corporation, New York, N. Y., a corporation of N. J

More specifically, the invention lies in the construction of a sheath for high tension electric cables, the sheath construction being such that it promptly follows variations in the volume of the contained insulating compound employed about the wires and expands to relieve the pressure within the sheath as the volume of the compound increases.

✦ ✦ ✦

No. 2,050,991, CABLE AND METHOD OF MAKING, Patented August 11, 1936 by Ralph W. Atkinson, Perth Amboy, N. J., assignor to General Cable Corporation, New York, N. Y., a corporation of N. J.

This cable construction bears a relationship to the cable construction disclosed in patent 2,050,990. While an electrostatic shield is provided, this is of such a thinness that it will inadequately carry the current of an electric power fault and liable to destruction for that reason. Accordingly, the inventor provides a strand of conducting material, grounded at its ends, within the body of insulation employed in the cable, the strand making contact with the electrostatic shield and being of a size adequate, in conjunction with the shielding layer of material employed, to carry the current of the electric power fault without damage to the shielding layer.

✦ ✦ ✦

Reissue 20,067, WIRE DRAWING APPARATUS, Patented August 18, 1936 by Herbert S. Busey, Providence, R. I., assignor to Kennecott Wire and Cable Company, Phillipsdale, R. I., a corporation of Rhode Island.

A die is provided having a flaring orifice and a jet for injecting fluid into the mouth of the orifice, the jet having its longitudinal axis disposed at its inclination to the longitudinal axis of the orifice and in a plane parallel therewith, so that fluid is caused to enter the mouth tangentially of its walls, to swirl around therein in a vortex, so as to flush out dirt, scale or other foreign matter therefrom.

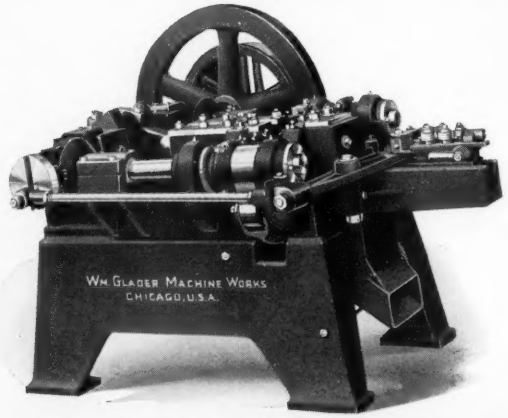
✦ ✦ ✦

No. 2,051,087, SPRING CUSHION CONSTRUCTION, Patented August 18, 1936 by Roy S. Jones, Anderson, Ind., assignor to The Barber Manufacturing Company, Anderson, Ind., a corporation.

This wire spring structure is stated to be particularly applicable to the cushions of chairs and the like.

(*Please turn to Page 602*)

HIGH SPEED WIRE NAIL MACHINE



WM. GLADER MACHINE WORKS

210 N. Racine Ave., Chicago, Illinois

The production figures shown below are guaranteed, but without exception they are exceeded in general mill practice.

SIZE MACH.	SIZE WIRE	MAX. LENGTH OF NAIL	NUMBER OF NAILS PER MIN.	CAP. IN POUNDS PER HR.
#00	#14	1¼"	550	55
#0	#12	1¾"	450	89
#1	#10	2½"	400	192
#2	#8	3½"	325	310
#3	#4	5"	225	523
#4	#1	7"	190	622
#4s	5/16"	9"	175	1155
#5	3/8"	12"	160	2400

This high output and economical operation account for the GLADER machine being accepted as standard equipment in all recent installations.

A Review of Recent Wire Patents

(*Continued from Page 601*)

No. 2,051,587, WIRE FABRIC MACHINE, Patented August 18, 1936 by Charles C. Wickwire, Cortland, N. Y., assignor to Wickwire Brothers, Cortland, N. Y., a corporation of N. Y.

This machine is of the type where wire strands are fed intermittently over a welding bar to produce diagonal mesh fabric, the inventor employs a wire carrier mechanism comprising an endless track disposed transversely of the path of travel of the strand, an endless connected series of wire carrier elements movable in the track and mechanism for imparting intermittent actuation to these elements to cause them to traverse the track.

No. 2,051,423, INSULATED CONDUCTOR, Patented August 18, 1936 by Elmer C. Schacht, Troy, N. Y., assignor to Behr-Manning Corporation, Troy, N. Y., a corporation of Mass.

A multi-strand insulated cable for low voltage is provided, the individual strands being coated with a mass of resilient and elastic particles and fibres, the particles and fibres being interlocked to form a cellular structure and to provide a rough exterior finish on the individual strands, so that the assembly of the individual strands forms air cells between the individual strands within the cable.

✦ ✦ ✦

No. 2,052,040, SPRING ASSEMBLY WITH FLAT GROOVED BORDER WIRE, Patented August 25, 1936 by Harry B. Sklar, Los Angeles, Calif.

In this spring assembly, there is a border wire with a section substantially cylindrical in cross section and having a horizontal groove and a lateral extension above the groove, the lower side of the groove having a lower lip. A coiled wire spring, having a loop, is fitted in the groove and bears against the flat surface of the extension, the lip of the border wire being bent upwardly to engage the loop of the spring wire.

✦ ✦ ✦

Anneal Your Wire Clean and Bright

By The Only Process That Does It

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With Real

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GET FULL INFORMATION FROM

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whether used for:

reeds or brushes; fence or stitching; pins or pinions; box or baling; nail or rivet; spring or mattress; to increase performance and pass each test LAVITE ANNEALED WIRE is always best.

Balloffet Expands

BECAUSE of the constantly increasing demand by the trade for Balloffet products, the **Balloffet Diamond Wire Dies Company, Inc.,** has recently completed erection of their new building which has enabled them to enlarge their manufacturing facilities. This new building located at 45-51 Adams Street, Guttenberg, N. J., occupies over 5,000 square feet of space.

✦ ✦ ✦

NEW and most modern precision equipment has been installed to insure scientific accuracy of every article made by Balloffet. Besides their wire drawing die business, they have been manufacturing, for some time, precision spray nozzles of every description.

✦ ✦ ✦

Exports and Imports

(*Continued from page 577*)

Leading Individual Outlet Continues to be Canada

CANADA'S trade aggregating 22,747 tons (including numerous items) continued in its position as the leading market, the chief products being plain shapes (4,378), skelp (3,395), black steel sheets (3,308), heavy rails (2,376), 'other steel bars' (2,112), and 'other plate' (1,404). Soviet Russia ranked second with purchases totaling 9,734 tons and the bulk was made up of black steel sheets (5,379), hot rolled strip steel (2,824), cold rolled strip (488), seamless boiler tubes (351), and 'other steel bars' (350). Mexico's receipts aggregating 7,559 tons followed, and the principal items were black steel sheets (1,531), tin plate (1,272), cast-iron pressure pipe and fittings (449), barbed wire (398), and car wheels and axles (360). Next in importance were ship-

(*Please turn to page 603*)

Cleaning Houses in the Wire Industry

(*Continued from page 575*)

which I am familiar, four of such installations are made with rubber lined tanks, five with the concrete shell and the acid resisting brick with Basolite or sulphur and one installation is made with wood tanks, which happens to be a copper mill.

✦ ✦ ✦

IMPROVEMENTS have been made in the manner in which acid is drawn out of the tank. The syphon jet in my opinion is the most satisfactory as it makes possible the building of a tank without any holes in the bottom or sides, and permits making repairs to the drain system at the least expense.

At the time of presentation before the Wire Association Meeting, this paper will include additional data on ventilation which was not compiled in time to include in this preprint.

Exports and Imports

(*Continued from page 602*)

ments to the Philippine Islands (5,933 tons), the predominating items being galvanized steel sheets (1,508), tin plate (877), galvanized steel welded pipe (674), 'other plate' (389), and black steel sheets (351). Japan was the fifth market of importance, its trade of 4,933 tons for the most part taking in ingots and blooms (2,967), tin plate (1,130), and wire rods (444). Cuba was next with a total of 4,205 tons, in which the outstanding items were heavy rails (967), tin plate (556), galvanized steel sheets (382), plain shapes (326), and barbed wire (325).

✦ ✦ ✦

Imports Continue Downward in July

RECEIPTS aggregated 38,350 tons valued at $1,600,760, thereby continuing the downward movement which set in during the previous month and at the same time recording declines of 4.4 percent in quantity and 3.4 percent in value from those coming in during that month. Pig iron recorded the sharpest decline when it fell 4,297 tons short of the June total.

Pig Iron Continues as Leading Import Item

PIG iron retained its position as the leading import item (excluding scrap) when 12,496 tons were received chiefly from British India (4,935), Canada (2,902), the Netherlands (2,231), Soviet Russia (1,147), and the United Kingdom (1,050). Next was spiegeleisen (4,011 tons) coming all from Canada (2,975), and Soviet Russia (1,136). Structural shapes (3,233 tons) — the next item of importance—were sent in mostly by Belgium (2,506), and France (666). Solid or hollow bars (2,453 tons) came principally from Belgium (1,794), and Sweden (330). 'Other hoops and bands' (2,000 tons) were supplied mostly

(*Please turn to page 608*)

There's NO SUBSTITUTE *for* GOOD WIRE *in cleaning*

Wissco Round and Flat Brush Wire is not ordinary wire. It is one of the special purpose Wissco Wires developed in the Wickwire Spencer Laboratories. It resists wear from abrasion, retains its stiffness and does not go "dead." Contrast these essential requirements of Wissco Brush Wire with those of perfectly soft annealed Wissco Florist Wire or high tensile Wissco Rope Wire. Yes, there is a special Wissco Wire best for every purpose including yours. Ask about it . . . today.

WICKWIRE SPENCER STEEL COMPANY

New York Worcester Buffalo Chicago San Francisco

WISSCO WIRE by Wickwire Spencer

For Better Dies For Every Job

Say

VASCOLOY ▲RAMET

The Tantalum Carbide Die Material • • •

Harder than the hardest of steels, immune to the action of most industrial acids, Vascoloy-Ramet is daily winning a wider acceptance throughout the wire world.

There is a Vascoloy-Ramet Die for every job, and especially for yours.

VANADIUM ALLOYS STEEL COMPANY
Vascoloy-Ramet Division
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New York	N. Y.
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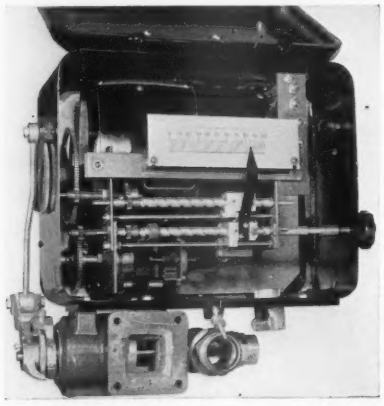
Providence	R. I.
Philadelphia	Pa.
Cleveland	Ohio
Detroit	Mich.
Chicago	Ill.
St. Louis	Mo.
Buffalo	N. Y.
Newark	N. J.
Knoxville	Tenn.
Los Angeles	Cal.
San Francisco	Cal.

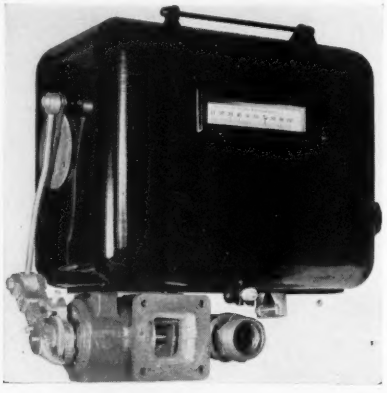
New Type of Temperature Control Unit

THE Lindberg Engineering Company announces an important development in temperature control equipment which is now offered to industry as the Lindberg Throttling Control. The new operating principle provides extremely sensitive control and results in amazing precision in heating.

✦ ✦ ✦

THIS is a fully automatic unit that operates on a new and revolutionary principle, assuring positive accuracy and uniformity in furnace heating rates. It definitely eliminates all possibility of drifting above or below the control temperature. It requires no manual adjustment and it has a complete range from zero to one hundred per cent valve opening. Thus the throttling principle becomes practical for use on batch furnaces and for other applications where a wide range of heat input is desired.





✦ ✦ ✦

THE Lindberg Throttling Control represents a distinct advance over former types of throttling controls which operated on the basis of varying the valve opening in relation to the deviation from control temperature. Under such limitations, the ranges were narrow, and it became necessary to make frequent adjustments for changes in heat requirements.

✦ ✦ ✦

THIS throttling control unit consists of a standard proportioning valve driven by a reversible motor. The low limit switch is fixed while the upper, or "O", switch is automatically adjusted by means of a small reversing motor, operated by the contacts on the control instrument. When the temperature is in neutral (between "L" and "H"), the valve remains fixed at the point set by the adjusting limit switch. The slightest tendency of the temperature to vary above or below neutral causes an immediate adjustment of the valve opening.

✦ ✦ ✦

THE amount of this adjustment is directly proportional to the time required for the temperature to retrieve normal. For example, if the temperature tends to move out of the neutral zone on the high side, the "H" contact instantly closes, shutting off the heat entirely and, at the same time, lowering the position of the adjustable limit switch. A large excess of heating rate will cause a large adjustment in the valve—and a small excess, a small adjustment accordingly. When the temperature returns to the neutral zone, the "H" contact opens; the limit switch ceases adjustment, and the valve opens to the newly set position.

✦ ✦ ✦

SHOULD the temperature tend to drop, the limit switch immediately moves to a more open position, the amount of the adjustment being in proportion to the time required for recovery. Thus the Control is never satisfied unless the temperature is exactly correct. As a result, over-shooting is practically eliminated, due to valve shutting off completely whenever there is the merest tendency for the temperature to exceed the control instrument setting.

AS an example, assuming the minimum valve opening to prevent back firing to be 20%, a mechanical stop is placed at this point in the travel of the adjusting limit switch. Then the heating rate is reduced below this point if necessary by the "on" and "off" method between the closed position and the 20% open position. The Lindberg Throttling Control puts the temperature "in a groove" and keeps it there automatically—with no manual adjustment whatever—and with no drift, drop or wabble.

✦ ✦ ✦

THE entire mechanism of this new instrument is mounted in a compact, dust-proof metal case with a glass-enclosed scale for indicating the extent of valve opening. The Lindberg Throttling Control will be on display at the Cleveland Exposition under the slogan, "Temperature, meet your Master."

✦ ✦ ✦

'Round the World With the Wire Industry

(*Continued from page 597*)

expire before the end of 1937, while the Association of German Wire Rope and Manufacturers is also to be prolonged effective with the opening of 1937. It is not believed, however, that these prolongations will be for more than one year.

✦ ✦ ✦

Establishment of International Wood Screw Cartel

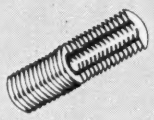
AN international cartel agreement of wood screw manufacturers for an indefinite period was recently entered in the Czechoslovak Cartel Register. The members include one British manufacturer, two Swedish firms and the Czechoslovak cartel of wood screw manufacturers. The purpose of the newly formed organization is to offer mutual protection to producers on the domestic and respective foreign markets.

To Those Registering and Attending the Wire Association Meetings stenographic copies of the discussions will be available at $2.50 per copy.

To all others $5.00 per copy.

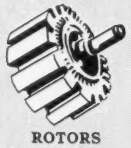
OXYGEN-FREE **OFHC** REG. U. S. PAT. OFF. HIGH CONDUCTIVITY

A SUPERIOR COPPER FOR ALL PURPOSES


FIN TUBES

BUS BARS

TROLLEY WIRE


ROTORS

The outstanding characteristics of OFHC COPPER are its freedom from oxygen and the uniformly fine quality of the castings produced by the Refinery.

Its freedom from oxygen gives OFHC COPPER greater ductility and toughness; making it especially well suited for all products which are subjected to severe fabricating or service conditions.

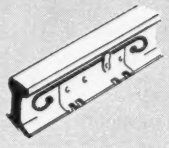
OFHC COPPER has greater resistance to impact stresses than ordinary electrolytic copper.

OFHC COPPER, because of its freedom from oxides, is better than ordinary electrolytic copper for welding and brazing.

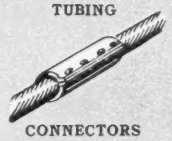
OFHC COPPER conforms to the A.S.T.M. Specification, B5-27, for electrolytic copper wire bars, cakes, etc. with regard to metal content and resistivity and is free from cuprous oxide.

Schedules of weights and dimensions of OFHC shapes, and a booklet containing technical information will be sent promptly on request.

WIRE


RAIL BONDS

TUBING


CONNECTORS

UNITED STATES METALS REFINING COMPANY
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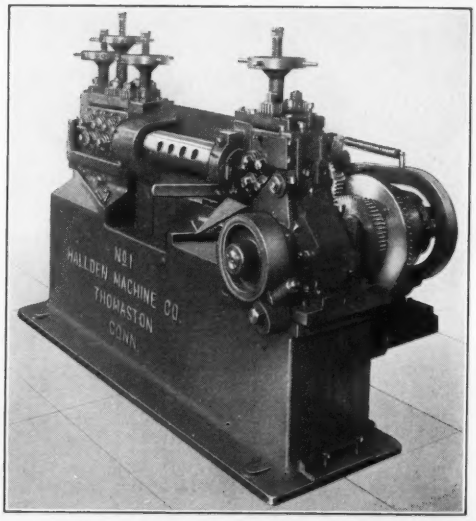
AUTOMATIC WIRE STRAIGHTENER
with
FLYING SHEAR



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Also high production, with accurate lengths.

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Builders of Wire and Cold Rolling Equipment

✦ ✦ ✦

Wire Blocks and Benches, Wire Flattening Mills, Levellers, Shears, Continuous Pickling Equipment, Tinning and Galvanizing Outfits.

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EVERY ROOM HAS PRIVATE BATH AND AT LEAST THREE LARGE WINDOWS

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As Low As
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FAIRBAIRN, INC.

A. S. M. E. Corrosion Resistant Metals Symposium

A REMARKABLE symposium on Corrosion Resistant Metals in Design of Machinery and Equipment will be held as part of the American Society of Mechanical Engineer's Annual Meeting in New York City, November 30 to December 4. The information presented is to be in compact form, of a practical nature, free from lengthy theoretical discussions but still sufficiently complete that when the different papers are assembled they will form a handy reference for the engineer of the subject of corrosion resistant metals.

✦ ✦ ✦

THE need for such a symposium was expressed by designing and operating engineers of the country who are constantly confronted with many problems on corrosion. They are busy men and not many of them have been able to follow closely the rapid development of this type of information during the past few years. Several of the professional divisions of the Society joined in developing the symposium making it a feature of the A.S.M.E. Annual Meeting where it has been allotted the whole day of Thursday, December 3 with three sessions in the morning, afternoon and evening. Mr. T. H. Wickenden, past chairman of the Society's Iron and Steel Division was appointed Chairman of the Committee that is arranging the symposium.

✦ ✦ ✦

SEVERAL methods of presentation had been considered to present the material but the most feasible appeared to be according to the different base metals.

✦ ✦ ✦

THE papers to be presented are as follows:

Introduction to Corrosion Resisting Metals—Dr. F. N. Speller, National Tube Co., Pittsburgh, Pa.

Alloys of Aluminum—E. H. Dix, Jr., Aluminum Company of America, New Kensington, Pa.

Nickel and Nickel-base Alloys—F. L. LaQue, The International Nickel Co., Inc., New York, N. Y.

Zinc in the Chemical Industries—E. A. Anderson, The New Jersey Zinc Company, Palmerton, Pa.

Lead—G. O. Hiers, National Lead Company, Brooklyn, N. Y.

Cast Iron in Chemical Equipment—Dr. H. L. Maxwell, E. I. du Pont de Nemours, Co., Inc., Wilmington, Del.

Copper and Copper-base Alloys—R. A. Wilkins, Revere Copper and Brass, Inc., Rome, N. Y.

Corrosion Resistant Steel (Stainless Type)—J. H. Critchett, Union Carbide and Carbon Research Laboratories, Inc., New York, N. Y.

✦ ✦ ✦

THE Committee drew up the following outline as a guide to the authors in the Symposium:

(1) Typical compositions (tabulated).
(2) Mechanical properties (tabulated)
(3) Available commercial forms, giving general information on whether the material is available in hot and cold rolled sheets, strip, bars, extruded, castings, forgings, etc., and some idea of the limiting sizes and gauges.
(4) Corrosive conditions for which the material is recommended as well as those for which it is not recommended. This information is to be presented as far as possible by means of tables, charts, or other means to present it in a condensed form. The following is a list of topics which should be covered as far as information is available in the corrosion data, giving some idea of its suitability, durability and range of rates of corrosion:
    Atmosphere
    Fresh water
    Salt water
    Neutral salts
    Mineral acids
    Oxidizing acids
    Organic acids
    Acid salts
    Alkaline salts
    Oxidizing acid salts
    Oxidizing alkaline salts
    Wet and Dry gases
(5) Information should be offered on recommended methods of fabrication, design, forming, joining, machining, etc.
(6) Typical examples of application in construction.

✦ ✦ ✦

THE **Midland Wire Corporation** has purchased a modern mill building at Tiffin, Ohio, where production of various types of Bare & Weather-Proof Line Wire will be under way by October 1st.

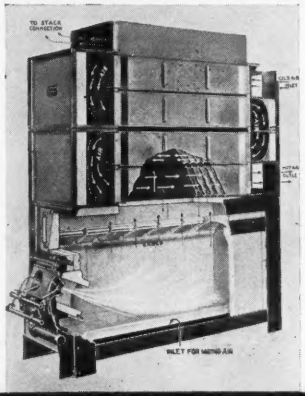
✦ ✦ ✦

PRINCIPAL officers of the new organization are **Arthur A. Mueller,** President, and **David R. Detwiler,** Vice-President and Treasurer, with whom are associated as Directors, men outstanding in the Alloyed Metals, Copper and Electrical Utilities Industries.

✦ ✦ ✦

THE company was wholly financed by those serving as Directors and is an "owner-operated" organization.

ROSS AIR HEATERS
for economical wire baking



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We keep for immediate delivery enormous stocks at low prices

New BALANCED SETS for High Speed Copper Wire Drawing
6000 feet a min. @ .010 size
Work more smoothly,
No Wire Breakage,
Stay on size much longer
Cost no more

Specially designed Dies now in stock for BRONZE, NICKEL, CHROME STAINLESS & HARD ALLOYS

Weight Guarantee given on all Vianney Dies.

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250 E. 43rd. St., New York City
Famous Wire Drawing Diamond Dies

APCO MOSSBERG CORPORATION
(FRANK MOSSBERG CORP.)
Lamb Street, ATTLEBORO, MASS.

Steel Spools for Annealing and Shipping
Steel Annealing and Stranding Reels
Steel Reels for Wire Rope
Steel Vulcanizing Reels
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✦ ✦ ✦

Manufacturers of a complete line of

STEEL REELS - BOBBINS - SPOOLS

for the Handling and Shipping of
COPPER and STEEL WIRE
Samples and Quotations upon Request

MILE A MINUTE MEASURING
of
WIRE AND ROPE
Now Possible With the New Model L-20 Productimeter

Increasing speed of production has demanded this accurate, heavy duty, mile a minute wire and rope measuring meter.

Capacity up to 1½" diameter

Write for New Catalog Section #3A

DURANT MFG. CO.
MILWAUKEE, WISC.

Exports and Imports

(*Continued from page 603*)

by Belgium (1,773), and Germany (216). 'Other pipe' represented the sixth outstanding item in the trade, the bulk coming from Germany (1,482), and Sweden (288).

✦ ✦ ✦

Where July Imports Came From

GERMANY was the leading supplier of iron and steel products (excluding scrap) to the United States in July, its trade (8,521 tons) consisting chiefly of nails, tacks, and staples (1,541), 'other pipe' (1,482), sheet piling (1,024), sheets, skelp, and sawplate (853), and hoops and bands for baling (706). Belgium followed with a trade aggregating 8,242 tons, the bulk of which being structural shapes (2,506), solid or hollow bars (1,794), 'other hoops and bands' (1,773), rails and track material (574), and sheets, skelp, and sawplate (413). Canada's trade (6,007 tons)—next in importance—was mostly of spiegeleisen (2,975) and pig iron (2,902). Receipts from British India (4,935 tons) were all of pig iron. The Netherlands sent in 2,644 tons, the bulk being of pig iron (2,231), and ferro-manganese (240). Sweden shared to the extent of 2,285 tons, the outstanding products being wire rods (699), solid or hollow bars (330), 'other pipe' (288), spong iron (252), and round iron and steel wire (247).

✦ ✦ ✦

A LOWER level of trade took place in card clothing when receipts (33,073 square feet valued at $46,722) declined (20.4 percent in quantity and 22.0 percent in value) from the June totals. This trade was covered chiefly by the United Kingdom (30,500 square feet valued at $40,611), and Germany (2,054 square feet valued at $4,388).

✦ ✦ ✦

A SET-BACK occurred in **wire cloth and screening** imports (86,907 square feet), when the July total declined 8.5 percent. The outstanding suppliers were Germany (39,713), Canada (17,081), the Netherlands (14,136), and Czechoslovakia (39,813).

FOURDRINIER and other paper-making wire was received to a total of 37,929 square feet as compared with 39,588 square feet in the previous month, and came from Germany (22,454), Austria (8,867), and Sweden (6,599).

✦ ✦ ✦

WIRE heddle imports at 467,000 pieces were considerably below the 1,232,000 pieces which came in during June. Sweden (300,000), and Germany (167,000) were the suppliers.

✦ ✦ ✦

A SHARP rise was registered in receipts of wire fencing and netting galvanized before weaving when 3,349,060 square feet were received (100,275 square feet in June) from Germany (2,501,110), and the Netherlands (329,925). Of the galvanized after weaving grade 554,865 square feet came in (277,875 square feet in June) mostly from Germany (436,000), the Netherlands (113,740), and the United Kingdom (4,500).

✦ ✦ ✦

EXPORTS of iron and steel wood screws during July, 1936 totaled 32,258 gross valued at $5,059. Of this total Cuba took 11,223 gross valued at $1,271; United Kingdom 8,323 gross valued at $1,332; Venezuela 3,011 gross valued at $453; Hong Kong 1,618 gross valued at $721; Brazil 1,270 gross valued at $168; Canada 1,176 gross valued at $161; Colombia 1,102 gross valued at $245.

✦ ✦ ✦

EXPORTS of brass wood screws during the same period amounted to 8,459 gross valued at $3,355. Of this total United Kingdom took 3,700 gross valued at $1,333; Cuba 2,401 gross valued at $869; Chile 823 gross valued at $260; Venezuela 427 gross valued at $235; Costa Rica 367 gross valued at $169.

✦ ✦ ✦

IMPORTS of wood screws during the same period amounted to 18,580 gross valued at $1,097, of which amount Japan supplied 14,480 gross valued at $798 and Belgium 4,100 gross valued at $299.

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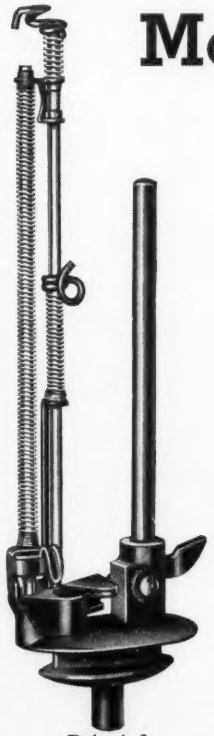

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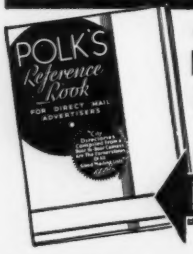

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Use International Standard Values In Compiling Copper Wire Tables

THE circular of the National Bureau of Standards giving copper wire tables, which has not been available for several years, is now being reprinted. Copies may soon be purchased from the Government Printing Office.

✦ ✦ ✦

THE tables in Circular 31, Copper Wire Tables, are in terms of the international standard values for the electrical resistivity temperature coefficient, and density of copper, adopted in 1913 by the International Electrotechnical Commission and based on research in the Bureau's laboratories, according to the Bureau's announcement. The history of the standard values is discussed in the circular.

✦ ✦ ✦

THE circular also gives considerable attention to wire gages, including a brief history of their development, trend of practice at the time the circular was prepared, and a detailed consideration of the American wire gage.

✦ ✦ ✦

THE tables are comprehensive, the Bureau's announcement says, and include, besides tables giving the relations of resistance, length, and mass for standard sizes, tables of standard resistivities and temperature coefficients, wire gages, cables, and aluminum wire. The data are duplicated in English and metric units.

✦ ✦ ✦

APPENDICES include the expression of the various kinds of resistivity and units thereof; calculation of the constant connecting the change of resistivity with the temperature, from the known law of proportionality between temperature coefficient and conductivity; data on the density of copper; calculation of the resistance and mass of cables; and the international standard of resistance for copper.

Plating Solution Control

IT is announced by the **Grasselli Chemical Company** that it is in a position to offer the trade test kits for the control of cadmium and zinc plating solutions. Three kits have been developed for this purpose:

For the determination of cadmium in cadmium-cyanide plating solutions.

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For the determination of the total sodium-cyanide content in zinc or cadmium plating solutions.

✦ ✦ ✦

AS nearly all previous methods of determining these constituents were either inaccurate, unreliable or intolerably slow, the company sought to develop a method that would be an accurate, reliable and quick means of finding the concentration of these constituents in the plating bath.

✦ ✦ ✦

IT is stated that these test sets are easy to manipulate. In organizations where centralized laboratory control is available it has been ascertained that the plater finds these test kits of great value, especially when the information they can give is required in a brief period of time.

✦ ✦ ✦

THESE tests sets for solution control supplement the Hull and Strausser test sets announced by Grasselli a few months ago for determining the thickness of electrodeposited cadmium or zinc coatings.

✦ ✦ ✦

WITH the increasing demand for coatings of specified thickness, these developments make it convenient for the plater to determine the composition of his plating bath and in that way keep it in the most efficient condition, enabling him to apply the specified coating thickness of cadmium or zinc in the minimum plating time.

✦ ✦ ✦

New Research Metallographic Outfit

A NEW research metallographic outfit has just been completed in the laboratories of Bausch & Lomb Optical Co., with complete equipment for work with bright field polarized light, and dark field.

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✦ ✦ ✦

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✦ ✦ ✦

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✦ ✦ ✦

THE supporting stand is provided with a top beneath which is located the shock-absorbing devices for carrying the equipment. The outfit can be supported on the shock absorbers or lifted off by adjusting levers located under the top portion of the supporting legs. A two-drawer cabinet in the right end of the table accommodates accessories and plate holders.

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Firth-Sterlings' New Sintered Carbide Plant

ABOVE is the designer's conception of the new building which the **Firth-Sterling Steel Company** has announced it will erect at its local plant as a result of increasing production demands.

✦ ✦ ✦

THE building is to be two stories in height and will be erected so that more floors can be added. It is to be used for the manufacture of tungsten carbide tools and dies, merchandising under the trade names of **"Firthaloy"** and **"Firthite."** It is to be 210 feet long, 95 feet wide and will be located adjacent to the existing buildings at Demmler in such a manner that it can be extended in three directions.

✦ ✦ ✦

THE construction of the new building has started and is designed in an ultra-modern style, in keeping with the Firthite-tungsten carbide process which is something new in the field of metallurgy. The building is to be equipped with dust removal and recovery system, and parts of it where the manufacturing process of tungsten carbide necessitates extremely hard wearing surfaces as well as clean working space the interior walls and floors will be given special finishes to meet these requirements and air will be filtered and conditioned.

✦ ✦ ✦

THE **Rust Engineering Company** of Pittsburgh has been awarded the contract for construction of the building and expects to complete the work the latter part of this year.

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✦

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&
DIAMOND
DIES

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Kelly Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Union Wire Die Corp., New York, N. Y.
Vanadium Alloys Steel Co., Pittsburgh, Pa.
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HOISTS—Electric Traveling
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HOISTS—Monorail
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Sleeper & Hartley, Inc., Worcester, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Bundling, Scrap
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.
Watson Machine Co., Paterson, N. J.

MACHINERY—Cable, Electric
American Insulating Machinery Co., Philadelphia, Pa.
Elevator Supplies Co., Inc., Hoboken, N. J.
New England Butt Co., Providence, R. I.
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Torrington Mfg. Co., Torrington, Conn.
Watson Machine Company, Paterson, N. J.

MACHINERY—Chain Making
Nilson, A. H., Machine Co., The, Bridgeport, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Closing
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Coil Winding
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., Torrington, Conn.

MACHINERY—Coilers
Broden Const. Co., Cleveland, O.
Elevator Supplies Co., Inc., Hoboken, N. J.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Const. Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Waterbury-Farrel Foundry & Machine Co. Waterbury, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Cold Heading With Wire Drawing Attachment
Ajax Manufacturing Co., Cleveland, O.

MACHINERY—Copper Wire Drawing and Rolling
Elevator Supplies Co., Inc., Hoboken, N. J.
Farrel-Birmingham Co., Ansonia, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Covering Wire—
Syncro Machine Co., Newark, N. J.

MACHINERY—Cutting
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Hallden Machine Co., Thomaston, Conn.
Nilson, A. H., Machine Co., The, Bridgeport, Conn.
F. B. Shuster Co., New Haven, Conn.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Worcester, Mass.

MACHINERY—Enameling
American Insulating Mach'y Co., Phila., Pa
Elevator Supplies Co., Inc., Hoboken, N. J.

MACHINERY—Extruding
John Robertson Co., Brooklyn, N. Y.
Watson Machine Co., Paterson, N. J.

MACHINERY—Flat Wire
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Forming
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Galvanizing Wire
Broden Construction Co., Cleveland, O.
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Gang Winders
H. J. Ruesch Machine Co., Newark, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Grinding
Norton Co., Worcester, Mass.

MACHINERY—Insulating
American Insulating Machinery Co., Phila.
Elevator Supplies Co., Inc., Hoboken, N. J.
New England Butt Co., Providence, R. I.
Syncro Machine Co., Newark, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Lead Encasing Presses, etc.
John Robertson Co., Brooklyn, N. Y.

MACHINERY—Lead Stripping
John Robertson Co., Brooklyn, N. Y.
Watson Machine Co., Paterson, N. J.

MACHINERY—Lock Washer
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Magnet Wire
American Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Hoboken, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Material Handling
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

MACHINERY—Measuring Wire & Cable
Davis, R. L., Electric Corp., Wallingford, Conn.
Durant Mfg. Co., Milwaukee, Wis., and Providence, R. I.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Nail and Tack
Glader, Wm., Machine Works Co., Chicago, Ill.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Panning
American Insulating Machinery Co., Phila.
Elevator Supplies Co., Inc., Hoboken, N. J.

MACHINERY—Pointing
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Hoboken, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
E. J. Scudder Foundry & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Rod Mill
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Const. Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.
Torrington Mfg. Co., Torrington, Conn.

MACHINERY—Rolling Mill
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Hoboken, N. J.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., Torrington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Rubber Strip Covering
Farrel-Birmingham Co., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Rubber Tubing and Straining
Farrel-Birmingham Co., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Screw Wire
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Special
American Insulating Mach'y Co., Phila. Pa.
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Hoboken, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
E. J. Scudder Foundry and Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Special—Combination Machine for Drawing, Cutting-to-length, Straightening and Reeling Bars from Coil in One Operation (Shumag Type)—
W. A. Schuyler, New York, N. Y.

MACHINERY—Spooling
American Insulating Machinery Co., Phila.
Elevator Supplies Co., Inc., Hoboken, N. J.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Spring Making
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Staple
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Straightening
Broden Construction Co., Cleveland, O.
Hallden Machine Co., Thomaston, Conn.
Nilson, A. H., Machine Co., The, Bridgeport, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.
F. B. Shuster, New Haven, Conn.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Stranding
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Strip Steel
Broden Const. Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.

MACHINERY—Swaging
Elevator Supplies Co., Inc., Hoboken, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Worcester, Mass.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Taping
Amer. Insulating Mach. Co., Phila., Pa.
Elevator Supplies Co., Inc., Hoboken, N. J.
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Testing Size of Wire
R. L. Davis Elec. Co., Wallingford, Conn.

MACHINERY—Testing Wire
Henry L. Scott Co., Providence, R. I.

MACHINERY—Tinsel Rolling Mills
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Hoboken, N. J.

MACHINERY—Trolley Wire
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Tube Mill
H. J. Ruesch Machine Co., Newark, N. J.

MACHINERY—Welding Wire
Micro Products Co., Chicago, Ill.
F. B. Shuster Co., New Haven, Conn.
Thomson-Judd Wire Machinery Co., Lynn, Mass.

MACHINERY—Winding
American Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Hoboken, N. J.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Wire Drawing
American Insulating Machinery Co., Phila.
Broden Const. Co., Cleveland, Ohio.
Elevator Supplies Co., Inc., Hoboken, N. J.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
E. J. Scudder Foundry & Machine Co., Trenton, N. J.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Standard Machinery Co., Providence, R. I.

BUYERS' GUIDE, Continued

Thomson-Judd Wire Machinery Co., Lynn, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Wire Rope
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Watson Machine Company, Paterson, N. J.

MACHINERY—Wire Tinning
American Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Hoboken, N. J.

MACHINERY—Wrapping Wire
W. A. Schuyler, New York, N. Y.

MATERIAL HANDLING EQUIPMENT—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

MILL—Rolling and Edging
Torrington Mfg. Co., Torrington, Conn.

MONORAIL SYSTEMS—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

NICKEL SILVER AND PHOSPHOR BRONZE—Rod, Wire and Strip
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

OVENS—Annealing or Drying
Lindberg Engineering Co., Chicago, Ill.
Ross Engineering Corp., New York, N. Y.

PAPER—Insulating
Manning, John A., Paper Co., Inc., Troy, N. Y.
E. W. Twitchell, Inc., Phila., Pa.

PATENT ATTORNEYS—
Lancaster, Allwine and Rommel, Washington, D. C.

PICKLING COMPOUNDS—
American Chemical Paint Co., Ambler, Pa.
Parkin Co., The Wm., Pittsburgh, Pa.

PICKLING—Tank Linings
American Hard Rubber Co., New York, N. Y.

POTS—Annealing, Case Hardening and Tempering
Lindberg Engineering Co., Chicago, Ill.

POTS—Lead Melting
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

PRESSES—Hydraulic and Mechanical
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

PRESSES—Lead
John Robertson Co., Brooklyn, N. Y.

PULLERS—Wire
E. J. Scudder Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.

PUMPS—Hydraulic
John Robertson Co., Brooklyn, N. Y.

REEL AND TENSION STAND—
Sleeper & Hartley, Inc., Worcester, Mass.

REEL CRUTCHES
Watson Machine Co., Paterson, N. J.

REELS—Annealing and Stranding
American Pulley Co., Philadelphia, Pa.
Apco Mossberg Co., Attleboro, Mass.
Hubbard Spool Co., Chicago, Ill.
Mossberg Pressed Steel Corp., Attleboro, Mass.

REELS—Impregnating
American Pulley Co., Philadelphia, Pa.
Apco Mossberg Co., Attleboro, Mass.
Hubbard Spool Co., Chicago, Ill.
Mossberg Pressed Steel Corp., Attleboro, Mass.

REELS—Steel
American Pulley Co., Philadelphia, Pa.
Apco Mossberg Co., Attleboro, Mass.
Hubbard Spool Co., Chicago, Ill.
Mossberg Pressed Steel Corp., Attleboro, Mass.

REFRACTORIES—High Temperature
Norton Co., Worcester, Mass.

ROD BAKERS—
Morrison Engineering Co., Cleveland, O.

RODS—Wire—Non Ferrous
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., Seymour, Conn.

RODS—Wire—Steel
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Co., Youngstown, O.
Wheeling Steel Corp., Wheeling, W. Va.
Wickwire Spencer Steel Co., N. Y. C.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

ROLLS—
Farrel-Birmingham Co., Ansonia, Conn.

RUST PROOF COMPOUND
American Lanolin Co., Lawrence, Mass.

SHEET—Steel
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Republic Steel Co., Youngstown, O.
Wheeling Steel Corp., Wheeling, W. Va.
Youngstown Sheet & Tube Co., Youngstown, O.

SOAPS—Wire Drawing
Amaloy Division of American Machine & Foundry Co., New York, N. Y.
R. H. Miller Co., Homer, N. Y.

SPOOLS—Steel
American Pulley Co., Philadelphia, Pa.
Apco Mossberg Co., Attleboro, Mass.
Hubbard Spool Co., Chicago, Ill.
Mossberg Pressed Steel Corp., Attleboro, Mass.

STRIP—Brass, Zinc and Non Ferrous
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., Seymour, Conn.

STRIP—Steel
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Firth-Sterling Steel Co., McKeesport, Pa.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Co., Youngstown, O.
Wheeling Steel Corp., Wheeling, W. Va.

TANKS—Compound
Watson Machine Co., Paterson, N. J.

TESTERS—Wire
Henry L. Scott Co., Providence, R. I.

TRAMRAIL SYSTEMS—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

TREADS—Safety
Norton Co., Worcester, Mass.

TRUCKS
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

TUBE BENDERS AND FORMERS
H. J. Ruesch Machine Co., Newark, N. J.

TURKS HEADS—
Standard Machinery Co., Providence, R. I.

VALVES AND FITTINGS—Acid Proof
Duriron Co., The, Dayton, O.

VULCANIZERS
Watson Machine Co., Paterson, N. J.

VULCANIZING PANS
American Insulating Mach'y Co., Phila., Pa.

WIRE—Cold Heading
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Corp., Youngstown, O.
Wheeling Steel Corp., Wheeling, W. Va.
Wickwire Spencer Steel Co., N. Y. C.
Youngstown Sheet & Tube Co., Youngstown, O.

WIRE—Electric
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.
Wickwire Spencer Steel Co., N. Y. C.

WIRE—Enameled For Coils
Winsted Div. of Hudson Wire Co., Winsted, Conn.

WIRE—Manufacturers
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Co., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Co., Youngstown, O.
Wheeling Steel Corp., Wheeling, W. Va.
Wickwire Spencer Steel Co., N. Y. C.
Youngstown Sheet & Tube Co., Youngstown, Ohio

WIRE—Nickel Silver and Phosphor Bronze
American Brass Co., Waterbury, Conn.
Hudson Wire Company, Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

WIRE—Non Ferrous to Specification For Special Purposes
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.
Winsted Div. of Hudson Wire Co., Winsted, Conn.

WIRE—Spring
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel and Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Co., Youngstown, O.
Seymour Mfg. Co., Seymour, Conn.
Wickwire Spencer Steel Co., N. Y. C.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Steel—Also Coppered Steel—Also Galvanized Steel
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Republic Steel Co., Youngstown, O.
Wheeling Steel Corp., Wheeling, W. Va.
Wickwire Spencer Steel Co., N. Y. C.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE AND STRIP—Brass, Zinc
Platt Bros. & Co., The, Waterbury, Conn.

WIRE—Weaving—Non-ferrous
American Brass Co., Waterbury, Conn.

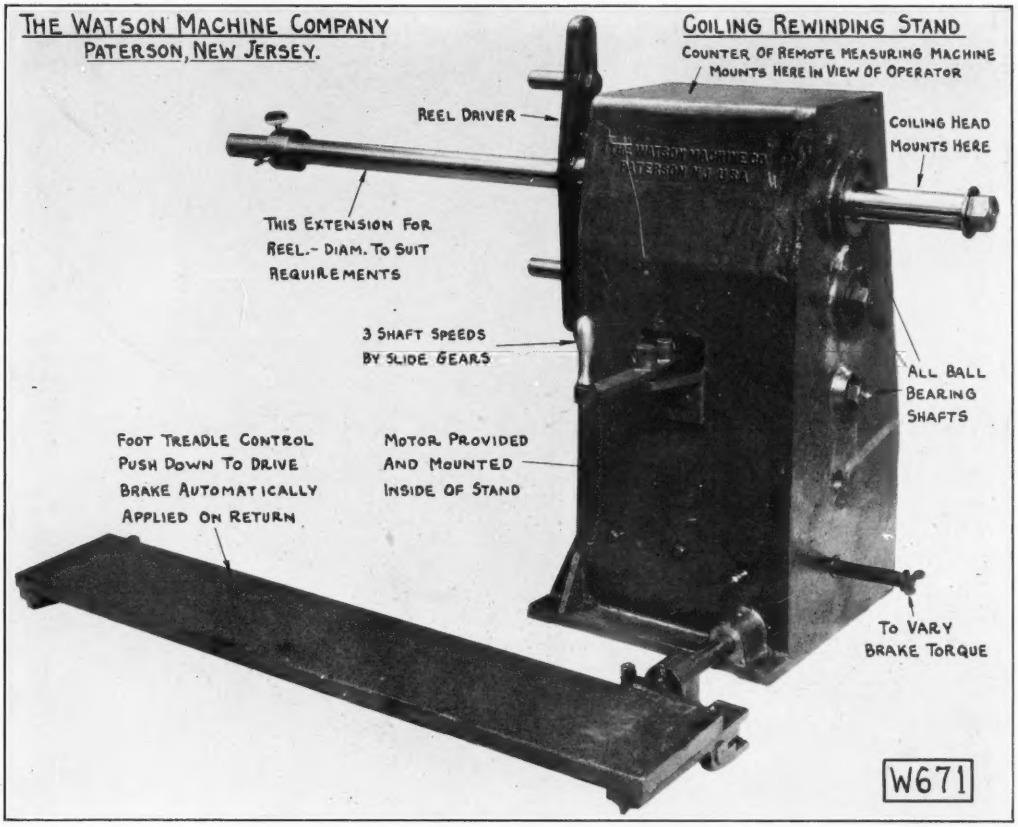
This is a carefully classified index of concerns who specialize in this industry and who advertise regularly in WIRE & WIRE PRODUCTS. Please mention WIRE when writing to these firms.

THE WATSON MACHINE COMPANY

ESTABLISHED 1845

PATERSON, NEW JERSEY, U. S. A.

REWINDING-COILING STRAND and COILING HEAD


THE WATSON MACHINE COMPANY
PATERSON, NEW JERSEY.
COILING REWINDING STAND
COUNTER OF REMOTE MEASURING MACHINE MOUNTS HERE IN VIEW OF OPERATOR
REEL DRIVER
COILING HEAD MOUNTS HERE
THIS EXTENSION FOR REEL.- DIAM. TO SUIT REQUIREMENTS
3 SHAFT SPEEDS BY SLIDE GEARS
ALL BALL BEARING SHAFTS
FOOT TREADLE CONTROL PUSH DOWN TO DRIVE BRAKE AUTOMATICALLY APPLIED ON RETURN
MOTOR PROVIDED AND MOUNTED INSIDE OF STAND
TO VARY BRAKE TORQUE
W671

THIS IS AN IDEAL UNIT FOR SHIPPING ROOM AND WAREHOUSE USE, combining Coiling and Reeling in the minimum of space.

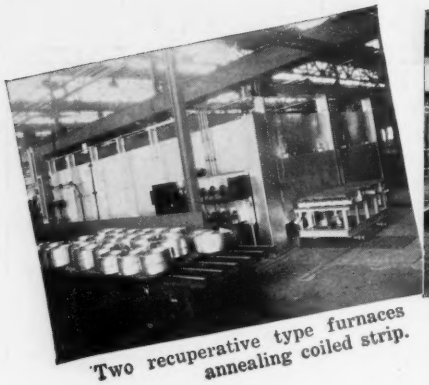
Installation cost reduced to that of wiring to the unit, as motor is provided installed inside of the stand.

Three speeds are quickly obtained by the slide gear change lever.

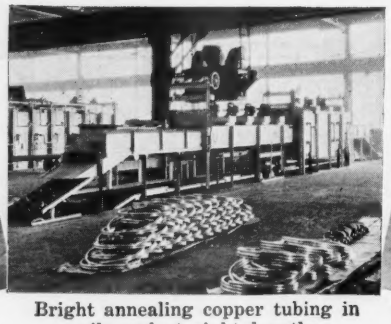
Main reel shaft is of heat treated steel, and reels whose weight in pounds multiplied by their overall width in inches does not exceed 75,000, can be carried without outer end support.

All shafts are ball bearing, and gears are cut.

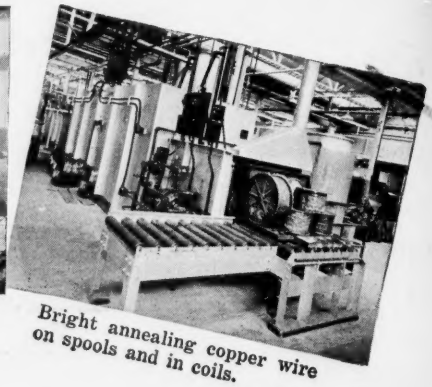
The foot treadle with automatic brake results in an extremely sensitive control, ideally suitable for this operation.



Two recuperative type furnaces annealing coiled strip.



Bright annealing copper tubing in coils and straight lengths.



Bright annealing copper wire on spools and in coils.

While You're In Cleveland

PERMIT us to show you installations of some of our outstanding furnaces and auxiliary equipment in Cleveland and vicinity. We have furnaces operating on practically every product and process.

Just tell us what kind of equipment you are interested in, or get in touch with one of our engineers at our booth (L-21 in the lower exhibition hall) at the National Metal Exposition. We will be glad to make arrangements for you to

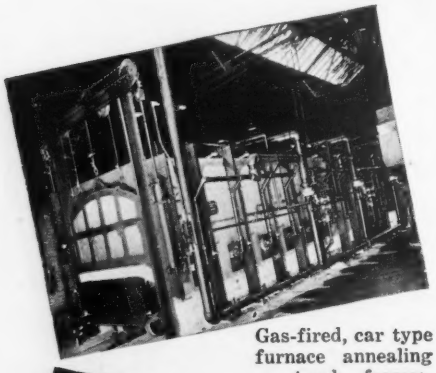
Inspect Some of Our Furnace Installations

ALSO see the large display of photographs showing various types of electric and fuel-fired furnace installations and material handling auxiliary equipment at our booth.

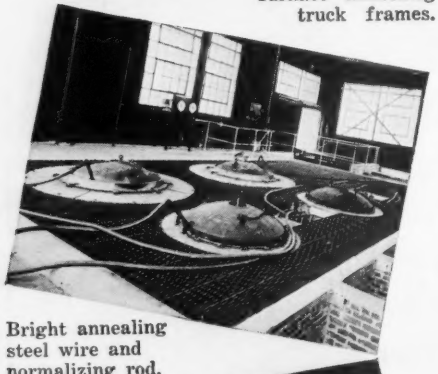
See the latest developments in special atmosphere equipment for bright and clean annealing various ferrous and non-ferrous products including tubing, wire, strip, sheet, stampings and other finished and unfinished products.

Also see the new continuous furnaces for copper brazing and for heating with complete absence of scale, as well as other continuous and batch furnaces of various types for normalizing, annealing, forging, billet heating and other processes.

Our engineers will be glad to work with you on any of YOUR annealing or heat treating problems.



Gas-fired, car type furnace annealing truck frames.

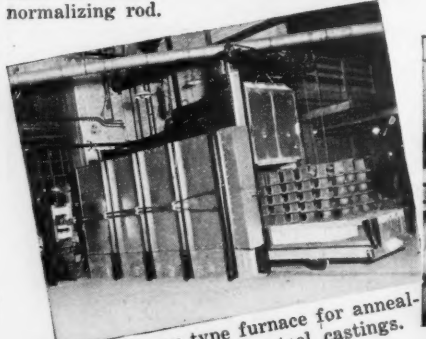


Bright annealing steel wire and normalizing rod.

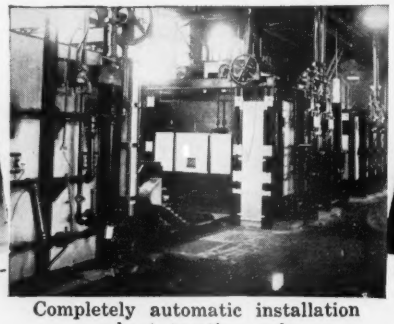
THE ELECTRIC FURNACE CO.
SALEM, OHIO.

Fuel-Fired Furnaces

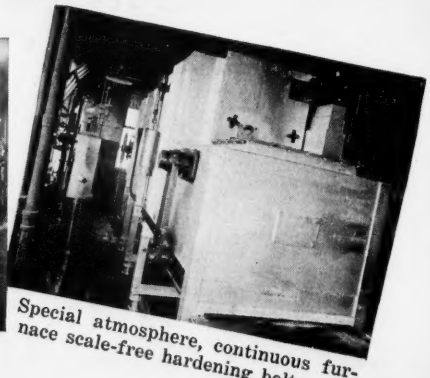
Electric Furnaces



Electric, car type furnace for annealing miscellaneous steel castings.



Completely automatic installation —heat treating axles.



Special atmosphere, continuous furnace scale-free hardening bolts, etc.